Научном већу Института за физику

Београд, 25. новембар 2015.

Предмет: Молба за покретање поступка за стицање звања научни саветник

С обзиром да испуњавам критеријуме прописане од стране Министарства просвете, науке и технолошког развоја за стицање звања научни саветник, молим Научно веће Института за физику да покрене поступак за мој избор у наведено звање.

У прилогу достављам:

1. Мишљење руководиоца пројекта
2. Кратку биографију
3. Преглед научне активности
4. Елементе за квалитативну оцену научног доприноса
5. Елементе за квантитативну оцену научног доприноса
6. Списак објављених радова и њихове копије
7. Податке о цитираности са Web of Science и Google Scholar
8. Списак и прилоге који који потврђују наводе у поднетим документима:

Са поштовањем,

др Миливоје Ивковић
Виши научни сарадник

Научном већу Института за физику

Београд, 25. новембар 2015.

Предмет: Мишљење руководиоца пројекта за избор др Миливоја Ивковића у звање научни саветник

Др Миливоје Ивковић је запослен у Лабораторији за спектроскопију плазме и ласере Института за физику од 5 октобра 1984. Он је ангажован на пројекту основних истраживања Министарства просвете, науке и технолошког развоја ОН 171014, под називом "*Спектроскопска дијагностика нискотемпературне плазме и гасних пражњења: облици спектралних линија и интеракција са површинама*". С обзиром да испуњава све предвиђене услове у складу са *Правилником о поступки и начину вредновања и квалитативном исказивању научних резултата истраживача* Министарства просвете, науке и технолошког развоја, сагласна сам са покретањем поступка за избор др Миливоја Ивковића у звање научни саветник.

За саств Комисије за избор др Миливоја Ивковића у звање научни саветник предлажем колеге:

(1) др Никола Коњевић, професор емеритус Физичког факултета Универзитета у Београду и редовни члан Српске Академије Наука и Уметности
(2) др Зоран Петровић, научни саветник, Институт за физику Београд и дописни члан Српске Академије Наука и Уметности;
(3) др Бранислав Јеленковић, научни саветник, Институт за физику Београд и дописни члан Српске Академије Наука и Уметности
(4) др Стевица Ђуровић, редовни професор Департмана за физику, Природно математичког факултета Универзитета у Новом Саду

Руководилац пројекта

Др Соња Јовићевић

Биографија: др Миливоје Ивковић

Миливоје (Радосав) Ивковић рођен је 22.11.1956 у Београду, где је завршио основну и средњу електротехничку школу "Никола Тесла". Електротехнички факултет - одсек Техничка физика завршио је одбраном дипломског рада **"Бљескалицама побуђен течни ласер са органским бојама**" јула 1983. године.

Стално је запослен од 05. 10. 1984. године у Лабораторији за спектроскопију плазме и физику ласера Института за физику Универзитета у Београду.

По одласку на служењу војног рока уписује постдипломске студије на Електротехничком факултету смер Оптоелектроника, који са успехом завршава (просечна оцена 10) одбраном магистарског рада са насловом **"Истраживање могућности пражњења са шупљом катодом за побуду молекуларних гасних ласера"** дана 28. 04. 1993.године. Изабран је у звање Истраживач сарадник 09. 04. 1996 године. У том периоду радио је превасходно у области физике, технологије и технике ласера учествујући на бројним научноистраживачким, развојним и војним пројектима.

У оквиру израде докторске дисертације он се бавио одређивањем Штарк-ових параметара ширења спектралних линија неутралних и једноструко и вишеструко јонизованих атома. Током истраживања њихове примене у дијагностици плазме радио је на конструкцији, развоју и упоредној анализи различитих извора плазме и електричних гасних пражњења, као и на развоју различитих техника аквизиције спектроскопских података. Кандидат је одбранио докторску дисертацију под насловом **"Оптичке емисионе спектроскопске технике дијагностике нискотемпературне плазме"** на Електротехничком факултету у Београду дана 25. 11. 2005, а у звање научни сарадник изабран је 05. 04. 2006 године.

Непрекидно је од 1984 године ангажован на основним истраживањима у оквиру различитих пројеката Министарства за науку Србије. Тренутно је ангажован на пројекту ОИ 171014: "Спектроскопска дијагностика ниско-температурне плазме и гасних пражњења: облици спектралних линија и интеракција са површинама". Коруководио је темом "Спектралне линије водоника и хелијумове линије са забрањеним компонетама за дијагностику плазме" из које су произашла и два прегледна рада. Бавио се и дијагностиком и применама ласерски произведених плазми за примене у аналитици и добијању нанокомпозита. У звање виши научни сарадник изабран је 25.05.2011.

Кандидат је током своје научне каријере публиковао 85 рада (17 од избора у претходно звање) и то: 22 (7) радова М21, 3 рада М22 и 3 (2) рада у М23. Осим тога публиковао је и 6 (1) уводна предавања на међународном конгресу - М31, затим 35 (2) рада на међународним конгресима штампана у целини – М33, и 5 (2) штампана у изводу – М34, као и 8 (1) рад у домаћим часописима – М51, 7 (2) рада на домаћим конференцијама штампана у целини – М63 и 3 рада штампана у изводу – М64.

Укупан научни допринос исказан М фактором износи 281.1 (72.5). Тотални импакт фактор радова је 65.742 (26.07), h-фактор 9 и преко 300 цитата, односно преко 200 цитата без хетероцитата.

Од децембра 2014. руководилац је Лабораторије за спектроскопију плазме и ласере Института за физику.

Руководио је израдом докторске дисертације Теодоре Гајо и мастер радова Милице Винић и Ане Драгојловић.

НАУЧНА И СТРУЧНА АКТИВНОСТ

Др Миливоје Ивковић бави се: спектроскопијом плазме од значаја за побуду гасних ласера и ласерски произведеном плазмом, проучавањем облика спектралних линија у плазми, дијагностиком плазме помоћу атомске емисионе спектроскопије, физиком и техником ласера и њиховим применама. У складу са наведеним научни и истраживачка рад др Миливоја Ивковића одвија се у три правца: а) физика, техника и примене ласера, б) спектроскопија плазме и в) дијагностика и примене ласерски произведене плазме.

1) ФИЗИКА, ТЕХНИКА И ПРИМЕНЕ ЛАСЕРА

Рад у овој области започео је још израдом дипломског рада *"Бљескалицама побуђен ласер са органским бојама"*, а потом је наставио учешћем у развоју и бројним примењеним истраживањима угљен диоксидних ласера и његових примена у оквиру наменских пројеката и за обраду неметала (рад М63-4). Рад наставља истраживањима у области интеракције ласерског зрачења са материјалима (радови М23-1, М33-1 и М33-5) а потом у области "Истраживања могућности коришћења пражњења са шупљом катодом за побуду молекуларних гасних ласера", што је и назив теме његовог магистарског рада. Део добијених резултата у овој области описан је и у радовима М21-1, М33-3 и М33-8.

У оквиру рада на бројним експерименталним мерењима облика и помераја спектралних линија као независна метода за одређивање густине електрона реафирмисана је метода ласерске интрферометрије. Постављни су у ту сврху интерферометри на бази хелијум неонског (М21-7 до 11 и 14, 16) и угљен диоксидног ласера (М21-2, М22-1).

Осим научног рада на основним истраживањима у областима физике ласера радио је и на примењеним истраживањима:

- Конструисање и израда CO_2 ласера за индустијске примене – модел 305, као и на оптимизацији услова за његову примену за обраду неметала (гума, пластика, дрво, папир...) у оквиру више пројеката финансираних од стране Технолошког фонда републичке заједнице за науку:
- Пројектовање затопљеног CO_2 ласера.
- Пројектовање и израда CO_2 ласера за примене у хирургији.
- Пројектовање и израда неодимијумског ласерског система велике снаге
- Војним применама ласера, превасходно у области оптоакустичке детекције гасова.
- Пројектовању He-Ne ласера снаге 2 mW у оквиру пројекта " Бар код ", финасираног од стране Савезног фонда за науку Југославије.

Кандидат се такође бавио и одржавањем и сервисирањем бројних ласерских уређаја за примене у медицини, различитим индустријама (електронској, графичкој и машинској) током постојања spin-off компаније Института за физику "ЛАСЕР ИНФИЗ" и касније самостално тј. хонорарно.

2) СПЕКТРОСКОПИЈА НИСКОТЕМПЕРАТУРНЕ ПЛАЗМЕ

Поред рада на конструкцији, развоју и упоредној анализи различитих извора плазме и електричних гасних пражњења попут: тињавог пражњења са воденом катодом (М63-1), ласерски индукованог импулсног пражњења (М23-3, М23-4, М51-1, М63-2, 6 и 7), капиларног пражњења (М21-8, 9 и 10), аргоном стабилисаног лука облика латиничног слова У (М33-23) и микроталасно индуковане плазме (М21-4, М21-6, М31-1, М33-12 до16, М33-18 и 19, М33-22, М51-2 до 5, М51-7, М63-3, М34-1 и М64-1) рад у овој области одвијао се превасходно на развоју и примени различитих импулсних пражњења на ниском притиску. Развојем и применама бројних извора за генерисање импулсних плазми, коришћењем различитих тиратрона и игнитрона омогућио је свој даљи рад на одређивању параметара ширења спектралних линија неутралних и јонизованих атома што је и главни истраживачки првавац кандидата.

2.1. Одређивање параметара ширења спектралних линија јонизованих атома

Кандидат се у оквиру ове теме поред експерименталних мерења облика линија једноструко и вишеструко јонизованих атома бавио и анализом метода за деконволуцији спектралних линија. Процесом деконволуцијемерених Воит-ових вршено је раздвајање утицаја ширења спектралних линија услед дејства електричног микро поља (Штарк-ово ширење) у плазми од утицаја: кретања емитера (Доплер-ово ширење), неутралних шестица (Ван дер Валс-ово ширење), као и природног, резонантног и инструменталног ширења. Посебна пажња посвећена је испитивањима правилности Штарк-овог ширења дуж изоелектронских низова угљеника (М21-8, М33-20 и М33-25) као и анализи ЛС спрезања (М33-27). На овај наћин експирементални одређени параметри поређени су са теоријским резултатима одређеним помоћу модификоване семиемпиријске и упрошћене семикласичне формуле и табелираним резултатима по семикласичној теорији. Посебна пажња посвећена је и проучавањима водонику сличног јона хелијума (М22-1).

2.2. Одређивање параметара ширења спектралних линија неутралних атома

У оквиру ове теме кандидат се поред експерименталних мерења и деконволуције комплексних облика профила спектралних линија неутралних атома хелијума, неона и криптона (М21-9 и 10) описаних функцијом j(A,R) бавио и анализом симултаног одређивања ширине линије услед судара са електронима као и параметра јонског ширења. Посебна пажња посвећивана је одређивању утицаја динамике јона на облик спектралних линија хелијума, као и утицају атомске масе на овај процес. Посебна пажња посвећена је и изучавањима помераја спектралних линија хелијума у густој нискотемпературној плазми (М21-21,22) у оквиру којих је и развијена нова метода базирана на специјално пројектованим и израђеним електродама импулсног пражњења на ниском притиску (М21-21)

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2.3. Спектралне линије водоника

Комплексност спектралних линија водоника условљена њиховом фином структром услед чега се могу приказати само у табеларном облику посебно су привукле пажњу кандидата. Поред програма за генерисање профила линија Балмерове серије водоника реализован је и програм за одређивање густине електрона у плазми поређењем теоријских и експерименталних профила Балмер бета линије (М21- 5), чија велика цитираност (преко 40) илуструје његову широку примену. Проучавања аномалног Доплеровог ширења линија водоника (М21-6 и 11), симултано одређивање густине и температуре електрона у плазми (М21-12) резултовале су и прегледним радом (М21-17). У овом прегледном раду је дата свеобухватна анализа утицаја фине структуре и осталих процеса ширења спектралних линија на профиле водоникових линија, и одређена грешка примене фитовања ових линија Воит-овим профилом. Растојање између пикова Балмер бета линије водоника предложено је као нова метода за дијагностику концентрације електрона и тестирање самоапсорпције у густим плазмама (М21-20).

2.4. Спектралне линије са забрањеним компонетама

Профили спектралних линија са забрањеним компонетама које одговарају прелазима забрањеним по селекционим правилима и услед комплексности се такође могу приказати само табеларно детаљно су проучаване у радовима кандидата. Највише су проучаване линије хелијума на 447.1 нм (М21-14 и 16) и на 492.2 нм (М21-17) али и линија литијума на 460.3 нм (М33-28). Анализирана је и посебно је истакнута важност коришћења растојања између дозвољене и забрањене компомнете ових линија за дијагностику оптички дебелих плазми.

2.5. Дијагностика густине електрона у нискотемпературској плазми

Облици и параметри ширења спектралних линија помоћу бројних метода описане у докторској дисертацији под насловом: *"Оптичке емисионе спектроскопске технике дијагностике густине електрона у нискотемпературској плазми"*. У оквиру рада у овој области најчешће је примењивана метода заснована на облику спектралних линија водоника: Балмер бета (М51-6, М33-12, М33-18, М64-2, М21-3 и 5) или Балмер гама (М22-2, М33-29 и М33-34). Испитиване су и критички евалуиране технике дијагностике плазме засноване на стапању линија на крају спектралне серије, затим на облицима и штарковим ширинама виших чланова водоникове Балмер серије. Истраживани су и облици и помераји хелијумових линија са забрањеним компонентама, а у циљу побољшања дијагностике гасних пражњења мерени су и поређени са моделом интензитети чела трака неутралног и јонизованог молекула азота. Детаљи поменутих истраживања објављени су у радовима М21-7, М33-21 и М33-24. Облици јонских линија хелијума (М22-1, М33-4, 6 и 9) и полуширине спектралних линија неводоничних јона дуж изо-електронског низа угљеника и њихова примена за одређивање густине електрона такође су разматране у докторској дисертацији и прегледном раду М21-7. Највећа пажња поклоњена је одређивању густине електрона из облика и полуширина линија неутралних неводоничних атома разних елемената (M21-9, M21-10), са нагласком на истраживање утицаја динамике јона на облик и померај линија (M21-2, M33-2, 7, 10 и 11). Овим методама одређивана је густина електрона у различитим раније поменутим изворима плазме, као и у изворима од значаја за примене (M21-19).

3) ПРИМЕНЕ И ДИЈАГНОСТИКА ЛАСЕРСКИ ПРОИЗВЕДЕНЕ ПЛАЗМЕ

Рад у области истраживањима интеракције ласерског зрачења са материјалима настављен је самосталним постављањем и покретањем експеримената у новој области - импулсне ласерске депозиције. Ова нова методе за генерисање како танких филмова, тако и различитих савремених материјала од важности у области нанотехнологија. Метода је демонстрирана креирањем нано-композита депоновањем угљеника на танкослојне полимерне субстрате (M63-5 и M64-3). Генерисањем нано честица злата величине од 6 до 15 nm и њиховом уградњом у такнослојне полимере ова се област даље развијала (M21-13, M34-2 и M34-3). Рад у овој области привремено је заустављен услед кашњења са набавком капиталне опреме (вакуум коморе са системима за ротацију мете, грејање субстрата, упуштање гаса итд.) и деструкције турбомолекуларне пумпе (наручене такође у оквиру набавке капиталне опреме) потребне за остваривање неопходног вакуума.

Знања из области интеракције ласерског зрачења са материјалима и спектроскопије и развоја импулсних пражњења примењена су и области аналитичке спектроскопије за побољшање прага детекције елемената. То је остварено коришћењем ласерске аблације мета за иницирање импуслног пражњења (M23-2,3). Проучавано је повећавање интензитета спектралних линија у цеви на ниском притиску при протоку различитих гасова (M23-1, M63-6) и у ваздуху (M23-1). Демонстрирана је и примена ове методе и на анализу земљишта (M63-7).

Искуства из области ласера и њихове интеракције са материјалима, као и из оптичке емисионе спектроскопије као непертурбативне методе примењена су у прегледном раду о дијагностици ласером генерисане плазме публиковане у часопису са импакт фактором преко 3.5 - Spectrochimica Acta Part B (M21-15).

ЕЛЕМЕНТИ ЗА КВАНТИТАТИВНУ ОЦЕНУ НАУЧНОГ ДОПРИНОСА КАНДИДАТА И МИНИМАЛНИ КВАНТИТАТИВНИ УСЛОВИ ЗА ИЗБОР

Категорија	Вредност коефицијента	Укупан број радова	Укупан број поена	Број радова од претходног избора	Број поена од претходног избора
М21	8	22	176	7	56
М22	5	3	15	1	5
М23	3	3	9	2	6
М31	3	5	15	0	0
М32	1.5	1	1.5	1	1.5
М33	1	35	35	2	2
М34	0.5	5	2.5	2	1
М51	2	8	14	1	0
М63	0.5	7	3.5	2	1
М64	0.2	3	0.6	0	0
М71	6		6		
М72	3		3		
УКУПНО:	**281.1**			**72.5**	

Диференцијални услов - од првог избора у претходно звање до избора у звање ...	... потребно је да кандидат има најмање XX поена, који треба да припадају следећим категоријама:		**Остварено**
Научни саветник	Укупно	**65**	**72.5**
	M10+M20+M31+M32+M33+M41+M 42 +M51>	**50**	**71.5**
	M11+M12+ M21+M22+ M23 +M24+M31+M32>	**35**	**66.5**

Укупни импакт фактор радова је **65.742** а од избора у претходно звање **26.07**
Укупан број страна ова 29 рада у М20 категорији је 252 тј преко 8 по раду.
Укупни импакт фактор радова је **65.742** односно преко 2.26 по раду.

Радови др Миливоја Ивковића су цитирани према:

Google Scholar 364 пута,
према Web of Science бази 278 без самоцитата 238,
а према Scopus 303 пута односно 252 без самоцитата и 203 без хетероцитата,

Његов h фактор износи 9.

ЕЛЕМЕНТИ ЗА КВАЛИТАТИВНУ ОЦЕНУ НАУЧНОГ ДОПРИНОСА КАНДИДАТА

1. Показатељи успеха у научном раду
1.1 Награде и признања за научни рад

Др Миливоје Ивковић има две номинације у изборима за рад године у часопису *Spectrochimica. Acta B* (импакт фактор 3.552 за 2010 годину) за радове:

а) M. Ivković, M. A. Gonzalez, S. Jovićević, M. A. Gigosos, N. Konjević
A simple line shape technique for electron number density diagnostics of helium and helium-seeded plasmas, Spectrochimica Acta Part B: **65**, 234 - 240 (2010).

б) N.Konjević, M.Ivković and N.Sakan,
Hydrogen Balmer lines for low electron number density plasma diagnostics, Spectrochimica. Acta B **76**, 16–26 (2012)

Подаци доступни на линк-овима:
http://dx.doi.org/10.1016/j.sab.2012.01.006
http://dx.doi.org/10.1016/j.sab.2014.02.004 и у Прилогу 1.

1.2 *Уводна предавања на конференцијама и друга предавања по позиву*

Кандидат је учествовао у шест уводних предавања од којих два као предавач и 4 као коаутор. Као доказ приложени су линк-ови до предавања (када они постоје) и текстови свих уводних предавања са насловном страном и садржајем - Прилог 2.

M31-3) http://publications.aob.rs/82/pdf/117-128.pdf
M31-4) http://link.aip.org/link/?APCPCS/876/301/1
M31-5) http://www.gbv.de/dms/tib-ub-hannover/726244481.pdf
M32-1) http://webhost.rcub.bg.ac.rs/~cespc2011/CESPC_Abstracts.pdf

1.3 Чланства у одборима међународних научних конференција и одборима научних друштава

Кандидат је од 2013 члан Научног комитета Summer School and International Symposium of Ionized Gases. Списак чланова Научног Комитета ове конференције може се наћи на линк-у
http://www.spig2014.ipb.ac.rs/committee.html и у Прилогу 3.

1.4 Чланства у уређивачким одборима часописа, уређивање монографија, рецензије научних радова и пројеката

Кандидат је рецензент за више часописа из области физике:

1) Spectrochimica Acta B (импакт фактор 3.552 за 2010 годину).
2) JQSRT – Journal of Quantitive Spectroscopy and Radiative Transfer (импакт фактор 3.193 за 2011 годину).
3) IEEE Transaction on Plasma Science
4) Journal of Research in Physics

Докази за неке од рецензија у виду: списка рецензија за SAB на Elsevier Editiorial System, захвалнице на рецензијима од едитора JQSRT и од едитора IEEE_ TPS налазе се у Прилогу 4.

2. Ангажованост у развоју услова за научни рад, образовању и формирању научних кадрова

2.1 Допринос развоју науке у земљи

Кандидат је руководилац Лабораторије за Спектроскопију плазме и ласере Института за физику Универзитета у Београду.

У области спектроскопије плазме покренуо је примену спектралних линија водоника и линија хелијума са забрањеним компонентама за дијагностику плазми. У области ласерски произведене плазме покренуо је нову тематику ласерске депозиције за креирање танких филмова и генерисање нанокомпозита.

Кандидат од 2004 године безпрекидно учествује на пројекту Српске Академије Наука и Уметности – *Облици и помераји спектралних линија у гасној плазми и гасним електричним пражњењима* о чему сведоче и Билтени САНУ. Насловне стране Билтена и странице у којима су приказани резултати тог пројекта по годинама приказани су у Прилогу 5.

2.2 Менторство при изради магистарских и докторских радова, руковођење специјалистичким радовима

Кандидат је коментор докторске дисертације Теодоре Гајо на Департману за физику Природноматематичког факултета у Новом Саду под насловом *Померај спектралних линија хелијума у густој нискотемпературској плазми*. Резултати су публиковани у радовима М21-21 и 22 у којима је кандидат аутор за коресподенцију, а он и докторант су по један пут првопотписани и другопотписани коаутори. Рад на писању дисертације је у току и одбрана се очекује у наредним месецима. Потврда о подобности теме и ментора дата је у Прилогу 6.

Коментор је и мастер рада Ане Драгојловић на Електротехничком факултету Универзитета у Београду под насловом *Фабрикација метал-полимер нанокомпозита* одбрањеног 30.09.2015 године – Прилог 7.

Кандидат је био и коментор мастер рада *"Могућности примене ЛИБС, за анализу земљишта"* (*17.7.2013)* и руководилац дипломског рада *под називом "Испитивање ласером индуковане плазме у атмосфери аргона" (17.7.2012. године)* Милице Винић на Факултету за физичку хемију Универзитета у Београду.

На Физичком факултету Универзутета у Београду био је ментор дипломског рада Елене Недановске под насловом *Временска и просторна анализа плазме при процесима ласерске аблације мета.* Изабран је на седници Научно наставног већа Физичког факултета у Београду одржаној 20.07.2007. за коментора магистарског рада Ивана Коралта под насловом *Истраживање облика Балмерових линија водоника у плазми при ниским електронским концентрацијама*. Експериментални део рада је при крају прекинут због одласка кандидата на докторске студије у Сједињене Америчке Државе. Кандидат је био и члан комисија за преглед и одбрану докторских дисертација Братислава Обрадовића (сада ванредног професора) и Јовице Јововића (сада научног сарадника) са Физичког факултета.

2.3 Педагошки рад

Учешће у образовању и формирању научног подмлатка.

Током јуна месеца 2009 године држао је на енглеском језику страним докторантима у Институту за физику 26 - часовни курс под називом "*Технологија гасних ласера*". Програм курса дат је у Прилогу 8.

Директор Института за физику је на захтев декана Департмана за физику Природноматематичког факултета Универзитета у Новом Саду дао сагласност кандидату за држање наставе из предмета *Оптички и оптометријски инструменти*, која није реализована услед изненадног погоршања кандидатове породичне ситуације. Сагластност је дата у Прилогу 9.

2.4 Међународна сарадња

Др Миливоје Ивковић учествовао је и на више међународних пројеката са:

- Институтом за молекуларну и атомску физику Академије наука Белорусије

1999-2002 BYu 1,2 Project with IMAF NAN Belarus on KSPU new generation building

- Универзитетом у Ваљадолиду финансиран од стране Министарства за науку и технологију Шпаније (Ministerio de ciencia y tecnologia Spain,

01.08.2006 – 12.12.2007. ENE2004-05038/FTN

12.12.2007 – 12.12.2010. ENE 2007-63386- FTN

Development of spectroscopic methods for diagnosis of plasmas in extreme conditions: very low and very high density plasmas, види Прилог 10.

- Националним институтом за ласере, плазму и физику зрачења из Букурешта, Румунија потписан између САНУ и Румунске академије наука

2008 – 2011 "Laser Generated Plasma: Spectroscopic Diagnostics and Applications in Thin Films Deposition and Characterization" , види Прилог 11.

- Билатерална сарадња са Републиком Француском за период 2012-2013 у оквиру пројекта Истраживање параметара Штарковог ширења спектралних линија неопходних за анализу материјала помоћу спектроскопије ласерски индукованог пробоја са Лабораторијомза Ласере, Плазми и Фотонске Процесе – LP3 (Laboaratorie Lasers, Plasmas et Procedes Photoniques) из Марсеја, види Прилог 12.

Др Миливоје Ивковић конкурисао је као руководиоц подпројекта Института за физику на FP7-REGPOT-2007-3 позиву са пројектом BIOPOLNANOTECH - Functional nanostructured biopolymer coatings for controlled drug delivery and advanced biomimetic metallic implants, који услед формалних разлога (текст пројекта предат, али се закаснило са потрвђивањем да је то финална верзија) није прихваћен за евалуацију, види Прилог 13.

2.5 Организација научних скупова

Кандидат је као члан Научног комитета Summer School and International Symposium of Ionized Gases и као рецензент и председавајући на једној секцији допринео организацији 27 SPIG-a одржаног у Београду 2014 године. Списак чланова Научног Комитета ове конференције може се наћи на линк-у
http://www.spig2014.ipb.ac.rs/committee.html и у Прилогу 3.

3. Организација научног рада

3.1 Руковођење пројектима, потпројектима и задацима

Др Миливоје Ивковић, у пројектном циклусу 2006 – 2010. године коруководио је темом: *"Спектралне линије водоника и хелијумове линије са забрањеним компонентама за дијагностику плазме"*, у оквиру научно-истраживачког пројекта основних истраживања *"Нискотемпературна плазма и пражњења: Радијациона својства и интеракција са површинама"*, **е**виденциони број ОИ141036.

Кандидат је у пројектном циклусу 2011 – 2015. године коруководио темом: *"Спектралне линије водоника и хелијумове линије са забрањеним компонентама за дијагностику плазме"*, у оквиру научно-истраживачког пројекта основних истраживања "*Спектроскопска дијагностика нискотемпературне плазме и гасних пражњења: облици спектралних линија и интеракција са површинама"*, **е**виденциони број ОИ171032. Овај пројекат предмет је *Уговора о реализацији и финансирању научноистраживачког пројекта и одржавања научноистраживачке опреме и простора за научноистраживачки рад*, за циклус истраживања у периоду 2011 – 2015.

Потврда о кооруковођењу темом у оквиру пројекта потписана од стране руководиоца пројекта дата је у Прилогу 14.

3.2 Технолошки пројекти, патенти, иновације и резултати примењени у пракси

Кандидат је учествовао у следећим примењеним истраживањима и применама:

- Конструисање и израда CO_2 ласера за индустијске примене – модел 305, као и на оптимизацији услова за његову примену за обраду неметала (гума, пластика, дрво, папир...) у оквиру више пројеката финансираних од стране Технолошког фонда републичке заједнице за науку:
- Пројектовање затопљеног CO_2 ласера.
- Пројектовање и израда CO_2 ласера за примене у хирургији.
- Пројектовање и израда неодимијумског ласерског система велике снаге
- Војним применама ласера.
- Пројектовању He-Ne ласера снаге 2 mW у оквиру пројекта " Бар код ", финасираног од стране Савезног фонда за науку Југославије.

4. Квалитет научних резултата

4.1 Утицајност

Кандидат је током своје научне каријере публиковао 85 рада (17 од избора у претходно звање) и то: 22 (7) радова М21, 3 рада М22 и 3 (2) рада у М23, односно укупно 28 рада (9) у категорији М20. Осим тога публиковао је и 6 (1) уводна предавања на међународном конгресу, затим 35 (2) рада на међународним конгресима штампана у целини – М33, и 5 (2) штампана у изводу – М34, као и 8 (1) рад у домаћим часописима – М51, 7 (2) рада на домаћим конференцијама штампана у целини – М63 и 3 рада штампана у изводу – М64. **Укупан научни допринос исказан М фактором износи 281.1 (72.5).**

Радови др Миливоја Ивковића су цитирани према подацима
Google Scholar 364 пута,
према Web of Science бази 278 без самоцитата 238,
а према Scopus 303 пута односно 252 без самоцитата и 203 без хетероцитата,
Треба напоменути да до осетних разлика у цитираности долази јер радове М21-2 и М22-1 индексна база Web of Science не препознаје, док рад М22-1 није препознат ни од индексне базе Scopus, иако су ови радови према бази Google Scholar вишеструко цитирани. Рад М21-2 је цитиран према Google Scholar 37 (WOS 0, SCOPUS 24), а рад М22-1 је према према Google Scholar цитиран 9 пута. (WOS 0, SCOPUS 0).

Кандидатов h фактор износи 9.
Преглед броја цитата премаиндексним базама дат је у Прилогу 15.

Овако велика цитираност довољно говори о утицају који су кандидатови радови имали у научној заједници.

4.2 Параметри квалитета часописа и позитивна цитираност кандидатових радова

Битан елемент за процену квалитета научних резултата је и квалитет часописа у којима су радови објављибвани, односно њихов импакт фактор ИФ, Укупни импакт фактор радова је **65.742** а од избора у претходно звање **26.07** односно преко **2.26** по раду. Последњи податак говори да је кандидат у периоду после избора у последње звање, а и генерално посматрано свој рад фокусирао на објављивање релативно мањег броја радова, али у најквалитенијим часописима у о његовој области истраживања.

О квалитету радова говори и да је укупан број страна ова 29 рада у М20 категорији је 252 тј преко 8 по раду. Ова чињеница говори да су скоро сви радови кандидата дали значајан допринос у његовој области истраживања.

О утицајности резултата научног рада кандидата говори и чињеница да су два рада кандидата номинована у изборима за рад године у часопису *Spectrochimica. Acta B* (импакт фактор 3.552 за 2010 годину).

На крају треба као најважнију илустрацији значаја радова кандидата истаћи чињеницу да су три рада прегледни радови и то у часопису из највише категорије М21 са импакт фактор 3.552 за 2010 годину (*Spectrochimica. Acta B).*

4.3 Ефективни број радова и број радова нормиран на основу броја коаутора

Сви радови кандидата су експерименталног карактера и немају преко седам коаутора, осим М51-8, па се могу узети са пуном тежином. Рад М51-8 укључен је у списак радова јер га препознају индексне базе, али је при одређивању квантитативних оцена доприноса кандидата узет са тежином 0 тј, није укључен у разматрање.

4.4 Степен самосталности и степен учешћа у реализацији радова у научним центрима у земљи и иностранству

Сви радови кандидата су урађени у Институту за физику у Београду. Посебно треба напоменути да су сви радови експерименталног карактера на апаратурама и помоћу извора плазме креираних у лабораторији, углавном уз већинску контрибуцију кандидата. Осим тога већина радова представља оргинални допринос кандидата увођењем нових тематика, попут импулсне ласерске депозиције, ласерском аблацијом иницираних пражњења и анализе спектралних линија водоника.

4.5 Значај радова

Кандидат је у свету препознат као настављач традиције београдске школе спектроскопије плазме и као експерт у области оптичке емисионе спектроскопије, посебно у области примене водоникових линија за дијагностику густине електрона у плазми. О овоме најбоље говоре три прегледна рада, две номинације за рад године, бројне рецензије итд. О његовом угледу говоре и чланства у комисијама за одбрану докторских дисертација на Физичком факултету у Универзитета Београду и чланство у научном одбору најзначајније домаће конференције у области физике јонизованих гасова.

4.6 Допринос кандидата реализацији коауторских радова

У свим радовима у којима је учествовао кандидат је дао изузетан допринос верфикован чињеницом да је у осам рада првопотписани,а у 11 другопотписани коаутор (од укупно 28 рада у категорији М20).

M21) PAPERS IN LEADING INTERNATIONAL JOURNALS – (SCI in best 30%)

1) M.Ivković, N.Konjević,
Glow-to-arc transitions in a hollow cathode CO_2 laser
Japanese Journal of Applied Physics vol. **34** (1995) Part I no. 10 (October) 5610 - 5614
DOI : http://dx.doi.org/10.1143/JJAP.34.5610
SCI = 1.363 (1992); M21 (14/48 – Physics, Applied)
1.275 (1998); M21 (19/66 – Physics, Applied) Cited by: 0

2) Z.Mijatović, N.Konjević, M.Ivković, R.Kobilarov,
Influence of ion dynamics on the width and shift of isolated He I lines in plasmas. II
Physical Review E **51**, 4891- 4896 (1995)
DOI: http://dx.doi.org/10.1103/PhysRevE.51.4891
SCI = 2.508 (2008); M21 (4/26 –Physics, fluids and plasmas);
Cited by: Google Scholar 37 (WOS 0, SCOPUS 24)

3) S.Jovićević, M.Ivković, Z.Pavlović, N.Konjević,
Parametric study of an atmospheric pressure microwave induced plasma of the Mini MIP torch: I. Two-dimensional spatially resolved electron number density measurements,
Spectrochim.Acta B **55**, 1879 - 93 (2000)
DOI: http://dx.doi.org/10.1016/S0584-8547(00)00285-8
SCI = 2.608 (2000); M21 (8/37 – Spectroscopy); Cited by: 31 (WOS 27, SCOPUS 29)

4) S.Jovićević, M.Ivković, N.Konjević,
Parametric study of an atmospheric pressure microwave induced plasma of the Mini MIP torch : II. Two-dimensional spatially resolved excitation temperature measurements,
Spectrochim.Acta B **56**, 2419 - 2428 (2001)
DOI: http://dx.doi.org /10.1016/S0584-8547(01)00305-6
SCI = 2.608 (2000); M21 (8/37 – Spectroscopy); Cited by: 12

5) R.Zikić, M.A.Gigosos, M.Ivković, M.A.Gonzalez, N.Konjević,
A program for the evaluation of electron number density from experimental hydrogen Balmer beta line profiles,
Spectrochim.Acta B **57**, 987 - 998 (2002)
DOI: http://dx.doi.org/10.1016/S0584-8547(02)00015-0
SCI = 2.695 (2002); M21 (7/38 – Spectroscopy); Cited by: 46 (WOS 41, SCOPUS 43)

6) S.Jovićević, M.Ivković N.Konjević, S.Popovic, L. Vuskovic,
Excessive Balmer line broadening in microwave-induced discharges,
Journal of Applied Physics **95**, (2004)
DOI: http://dx.doi.org/10.1063/1.1629133
SCI=2.498 (2005) (M21 - 12/83– Physics, Applied) Cited by: 29 (WOS 25, SCOPUS 24)

7) M.Ivković, S. Jovićević, N. Konjević:
Low electron density diagnostics: development of optical emission spectroscopic techniques and some applications to microwave induced plasmas, ***REVIEW***
Spectrochimica Acta B **59**, 591 - 605, (2004)
DOI: http://dx.doi.org/10.1016/j.sab.2004.02.005
SCI = 3.086 (2004); M21 (7/39 – Spectroscopy); Cited by: 58 (WOS 55, SCOPUS 56)

8) M.Ivković, N.Ben Nessib, N.Konjević
Stark broadening of 3s $^3P^0$ - 3p ^3D and 3p ^3D - 3d $^3F^0$ transitions along carbon isoelectronic sequences of ions, revisited,
J. Phys. B: At. Mol. Opt. Phys. **38** (2005) 715 - 728
DOI: http://dx.doi.org/10.1088/0953-4075/38/6/010
SCI = 2.024 (2006); M21 (9/55 – Optics); Cited by: 6

9) S Jovićević, M Ivković, R Zikic, N Konjević
On the Stark broadening of Ne I lines and quasi-static versus ion impact approximation,
J. Phys. B: At. Mol. Opt. Phys. **38**, 1249 - 1259 (2005)
DOI: http://dx.doi.org/10.1088/0953-4075/38/8/014
SCI = 2.024 (2006); M21 (9/55 – Optics); Cited by: 8

10) M Ivković, R Zikic, S Jovićević, N Konjević,
On simultaneous determination of electron impact width, ion-broadening and ion-dynamic parameter from the shape of plasma broadened non-hydrogenic atom line
J. Phys. B: At. Mol. Opt. Phys. **39** (2006) 1773 - 1785
DOI: http://dx.doi.org/10.1088/0953-4075/39/7/019
SCI = 2.024 (2006); M21 (9/55 – Optics); Cited by: 3

11) S. Jovićević, N. Sakan, M. Ivković, N. Konjević
Spectroscopic study of hydrogen Balmer lines in a microwave induced discharge
Journal of Applied Physics **105**, 013306 (2009).
DOI: http://dx.doi.org/10.1063/1.1629133
SCI = 2.201 (2008) (M21 - 20/96 – Physics, Applied). Cited by: 7

12) N Konjević, S.Jovićević and M. Ivković
Optical emission spectroscopy for simultaneous measurement of plasma electron density and temperature in a low-pressure microwave induced plasma.
Physics of plasmas **16**, 103501, (2009).
DOI: http://dx.doi.org/10.1063/1.3240325
SCI = 2.475 (2009); M21 (6/28 – Physics, fluids & plasmas); Cited by: 8

13) D. K. Božanić, M. Ivković, N. Bibić, J. Hegewald, J. Piontecký, R.Žikić, V. Djoković
PS-NH2+PMMA-COOH blend: a promising substrate material for the deposition of densely packed gold nanoparticles
Phys. Status Solidi RRL **4**, 85 - 87 (2010).
DOI: http://dx.doi.org/10.1002/pssr.201004046
SCI = 2.815 (2010) M21 (40/225 – Material science, Multidisciplinary; Cited by: 0

14) M. Ivković, M. A. Gonzalez, S. Jovićević, M. A. Gigosos, N. Konjević
A simple line shape technique for electron number density diagnostics of helium and helium-seeded plasmas
Spectrochimica Acta Part B: **65**, 234 - 240 (2010)
DOI: http://dx.doi.org/10.1016/j.sab.2010.03.003
SCI = 3.552 (2010); M21 (7/42 – Spectroscopy); Cited by: 16 (WOS 14, SCOPUS 16)

15) N. Konjević, M. Ivković and S. Jovićević
Spectroscopic diagnostics of laser-induced plasmas ***REVIEW***
Spectrochimica Acta Part B: **65**, 593 - 502 (2010)
DOI: http://dx.doi.org/10.1016/j.sab.2010.03.009
SCI = 3.552 (2010); M21 (7/42 – Spectroscopy); Cited by: 40 ( ) (WOS 36, SCOPUS 34)

16) M.Á González, M. Ivković, M.A Gigosos, S. Jovićević, N. Lara and N. Konjević
Plasma diagnostics using the He I 447.1 nm line at high and low densities
J. Phys. D: Appl. Phys. **44** 194010 (2011)
doi: http://dx.doi.org/10.1088/0022-3727/44/19/194010
SCI = 2.544 (2011) (M21 - 26/125 – Physics, Applied). Cited by: 6

17). N.Konjević, M.Ivković and N.Sakan,
Hydrogen Balmer lines for low electron number density plasma diagnostics, ***REVIEW***
Spectrochimica. Acta B **76**, 16–26 (2012)
DOI:**:** http://dx.doi.org /10.1016/j.sab.2012.06.026
SCI: = 3.552 (2010) (M21 7/42) Cited by 39 (WOS 30, SCOPUS 31)

18) M. Ivković, M. A. Gonzalez, N. Lara, M. A. Gigosos, N. Konjević,
Stark broadening of the He I 492.2 nm line with forbidden components in dense low-temperature plasma,
JQSRT **127** (2013) p.82-89
http://dx.doi.org/10.1016/j.jqsrt.2013.04.030 IF = 3.13 (2011) ; 2.38(2012)
SCI = 3.193 (2011) (M21 10/42) Cited by: 4

19) Volodymyr Shapoval, Ester Marotta, Claudio Ceretta, Nikola Konjevic, Milivoje Ivkovic, Milko Schiorlin, Cristina Paradisi,
Development and Testing of a Self-Triggered Spark Reactor for Plasma Driven Dry Reforming of Methane,
Plasma Process. Polym. **11** (2014) 725.
DOI: http://dx.doi.org /10.1016/j.sab.2012.06.026/10.1002/ppap.201400007
SCI = 3.73 (M21 21/128) Cited by: 1 (1)

20) Milivoje Ivković, NikolaKonjević, ZoranPavlović,
Hydrogen Balmer beta: The separation between line peaks for plasma electron density diagnostics and self-absorption test
Journal of Quantitative Spectroscopy & Radiative Transfer 154(2015)1–8
DOI: http://dx.doi.org/10.1016/j.jqsrt.2014.11.014
SCI = 2.645 (2014) (M21 12/44) Cited by: 6

21) M. Ivković, T. Gajo, I. Savić and N. Konjević,
The discharge for plasma Stark shift measurement and results for He I 706.522 nm line
Journal of Quantitative Spectroscopy & Radiative Transfer 161 (2015) 197 - 202
doi: http://dx.doi.org/10.1016/j.jqsrt.2015.04.010
SCI = 2.645 (2014) (M21 12/44) Cited by: 1

22) T. Gajo, M. Ivkovic, N. Konjevic, I. Savic, S. Djurovic, Z. Mijatovic and R. Kobilarov,
Stark shift of neutral helium lines in low temperature dense plasma and the influence of Debye shielding
MNRAS (2015) **455,** 2969–2979.
http://dx.doi.org/10.1093/mnras/stv2549
SCI = 5.107 (2014) (M21 12/60) Cited by: 0

M22) PAPERS IN LEADING INTERNATIONAL JOURNALS – SCI in best 50%)

1) I.Stefanović, M.Ivković, N.Konjević
Experimental study of the influence of ion-dynamics to the shape of He II P_α and P_β lines,
Physica scripta **52**, 178 - 183 (1995)
http://dx.doi.org/10.1088/0031-8949/52/2/007
SCI = 0.878 (1992); M22 (30/64 – Physics) **Cited by: 9 (WOS 0, SCOPUS 0)**

2) Z.Mijatović, D. Nikolić, R.Kobilarov and M.Ivković
Stark broadening of the hydrogen Hgamma spectral line at moderately low plasma electron density
JQSRT **111**, 990 - 996, (2010).
DOI: http://dx.doi.org/10.1016/j.jqsrt.2010.01.005
SCI = 1.862 (2009); M22 (17/39 - Spectroscopy) Cited by: 2

3) B. M. Obradovic, M. Ivkovic, S. S. Ivkovic, N. Cvetanovic, G. B. Sretenovic, V. V. Kovacevic, I. B. Krstic and M. M. Kuraica
Nonuniform Laboratory Plasmas and Stark Shift Measurement,
Astrophysics and Space Science
DOI 10.1007/s10509-015-2620-0
SCI =2.263 (2014) (M22 25/60) Cited by: 0

M23) PAPERS IN INTERNATIONAL JOURNALS –(on SCI list)

1) M.Srećković,V.Šijački- Žeravčić, N.Ivanović, N.Backović, V.Vedlin, M.Ivković, and S.Ristić
Laser damage in ferrites of MnSn spinels and other possible interactions
Optics and Lasers in Engineering **27**, 507 -522 (1997).
DOI: http://dx.doi.org/10.1016/S0143-8166(96)00037-1
SCI= 0.333(1998); M23(37/47- Optics); = 0.275(1992); M23(22/30- Optics) Cited by: 0

2) M. Vinić and M. Ivković,
Laser ablation initiated fast discharge for spectrochemical applications,
Hemijska industrija **68 (**2014)381 - 388
DOI: http://dx.doi.org/10.2298/HEMIND130314065V (M23) IF=
SCI = 0.562 (2014) (m23 103/133) Cited by: 0

3) Milica Vinic and Milivoje Ivkovic
Spatial and Temporal Characteristics of Laser Ablation Combined With Fast Pulse Discharge
IEEE Transation on Plasma Science 42 (2014) 2598 -2599
DOI: 10.1109/TPS.2014.2330372
SCI = 1.101 (2014) (M23 21/31) Cited by: 0

M31) INVITED LECTURES -

1. S.Jovićević, M.Ivković, N.Konjević:
"Parametric study of an atmospheric pressure microwave induced plasma of the mini MIP torch",
Invited Lecture, IV Yugoslav-Belarussian Symposium on Physics and Diagnostics of Laboratory and Astrophysical Plasmas, Belgrade 23-24 August 2002, Eds.: M.Ćuk, L.M.Popović and V.S.Burakov, Publ.Astron.Obs.Belgrade 74, 37-52, 2002.

2. N.Konjević, M.Ivković, S.Jovićević,
Application of hydrogenic and non-hydrogenic spectral line shapes for low electron density plasma diagnostics,
4th Conference on Plasma Physics and Plasma Technology (PPPT-4), Minsk 14-19 September 2003, Invited lecture, four pages summary in Contributed papers published by Institute of Molecular and Atomic Physics National Academy of Sciences Belarus (2003) pp. 329-32.

3. M.Ivković, S.Jovićević, R.Zikic and N.Konjević
Applications of spectral lines for low electron density plasma diagnostics,
Invited Lecture, VI Yugoslav-Belarussian Symposium on Physics and Diagnostics of Laboratory and Astrophysical Plasmas, Belgrade 22 -25th August 2006,
Publ. Astron. Obs. Belgrade No. 82 (2007), 117-128 link

4. M.Ivković
Optical emission spectroscopic techniques for low-electron density diagnostics
Invited lecture - Progres Report. 23 SPIG Kopaonik 28 August- 1 september 2006. AIP Conf. Proc.- December 1, 2006 – Volume 876, pp. 301-308
THE PHYSICS OF IONIZED GASES: 23rd Summer School and International Symposium on the Physics of Ionized Gases; Invited Lectures, Topical Invited Lectures and Progress Reports; doi:10.1063/1.2406039 Issue Date: 1 December 2006 link

5. Konjevic Nikola M Ivkovic Milivoje R Jovicevic Sonja
Low-electron Density Plasma Diagnostics By Optical Emission Technique
17th Symposium on physics of switching arc, 10 – 13 September, 2007, Brno, Czech Republic, vol II: Invited papers, (2007), str. 27-36 link

M32) INVITED LECTURES – published as abstracts

1) N.Konjević and M.Ivković.
On the application of optical emission spectroscopy for low electron density plasma diagnostics,
Fourth Central European Symposium on Plasma Chemistry, August 21-25, 20011. Zlatibor, Serbia, Book of Abstracts Eds. M.M.Kuraica and B.Obradović, Belgrade (2011) p. 15-16, Printed by MINERVA, , Subotica, ISBN 978-86-84539-08-5

M33) PAPERS AT INTERNATIONAL CONFERENCES

1) M.Srećković, O.Žižić, N.Ivanović, M.Ivković, Z.Janevski, B.Vedlin, R.Bulgarinović, R.Stepić, A.Kunosić
Problems of Hg1-xMnxSe and MnZn ferrites solved by means of laser spectroscopy and acoustooptical coupling,
13th International Congress on Acoustics Jugoslavija, Beograd,24-31 avg. 1989 (365-370)

2) Z.Mijatović, R.Kobilarov, M.Ivković, N.Konjević
Influence of ion dynamics to the width of HeI 667,8 nm line
11th International Conference on Spectral Line Shapes, Francuska, Carry le Rouet, 8 - 12 jun 1992, (A27-28)

3) M.Ivković, N.Konjević
Hollow cathode glow discharge for CO_2 lasers
21th International Conference on Phenomena in Ionized Gases, Germany, Bochum, 19-24 sept.1993, (96-97)

4) I.Stefanović, M.Ivković
The influence of ion dynamics on the line shape of HeII 320.3 nm line
16th International Symposium of the Physics of Ionized Gases, Jugoslavija, Beograd, 25-28 sept. 1993, (206-208)

5) M.Srećković, V.Šijački-Žeravić, M.Ivković, Z.Janevski, I.Belić, Z.Fidanovski, T.Jokić, Z. Andjelković, D.Mamula
Critical points of the laser processing and the reliability
6th Conferenta de techologii neconventionale, Romania, Temisoara, 28 - 29oct. 1993 (145 - 150)

6) I.Stefanović, M.Ivković N.Konjević
Experimental study of He II P_β line shape
12th International Conference on Spectral Line Shapes,Canada, Toronto,13-17th june 1994, paper (PB-1) or in
Spectral Line shapes vol. 8 - Editors A. David May,J.R.Drummond,Eugene Oks,p.58.
http://link.aip.org/link/?APCPCS/328/58/1

7) Z.Mijatović, N.Konjević, R.Kobilarov, M.Ivković
Influence of ion-dynamics on the shape of the He I 4713 and 7065 lines
12th International Conference on Spectral Line Shapes,Canada, Toronto, 13 - 17th june 1994, paper (PB-2) or in
Spectral Line shapes vol. 8 - Editors A.David May,J.R.Drummond, Eugene Oks,p.60.
http://link.aip.org/link/?APCPCS/328/60/1

8) M.Ivković, N.Konjević
The instatibilities in the hollow-cathode glow discharge CO_2 laser
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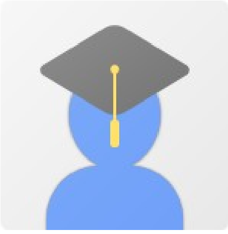

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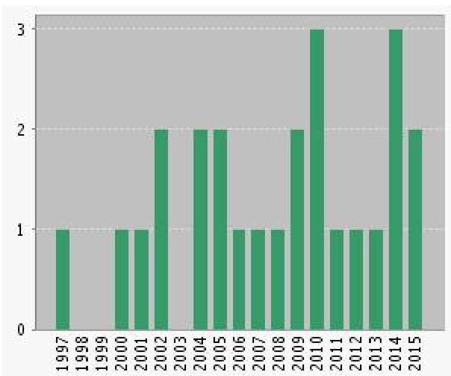

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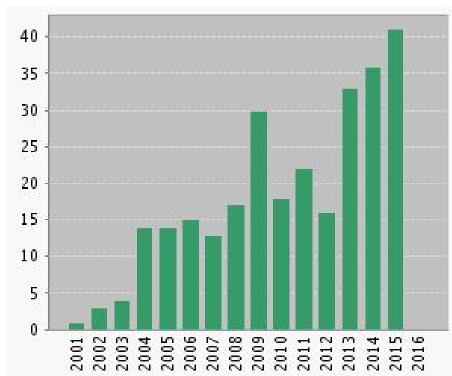

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8.	**Parametric study of an atmospheric pressure microwave-induced plasma of the mini MIP torch - II. Two-dimensional spatially resolved excitation temperature measurements** By: Jovicevic, S; Ivkovic, M; Konjevic, N SPECTROCHIMICA ACTA PART B-ATOMIC SPECTROSCOPY Volume: 56 Issue: 12 Pages: 2419-2428 Published: DEC 10 2001	0	0	1	0	0	11	0.73
9.	**Spectroscopic study of hydrogen Balmer lines in a microwave-induced discharge** By: Jovicevic, S.; Sakan, N.; Ivkovic, M.; et al. JOURNAL OF APPLIED PHYSICS Volume: 105 Issue: 1 Article Number: 013306 Published: JAN 1 2009	0	0	1	0	0	7	1.00
10.	**Plasma diagnostics using the He I 447.1 nm line at high and low densities** By: Gonzalez, Manuel A.; Ivkovic, Milivoje; Gigosos, Marco A.; et al. Conference: 11th High-Tech Plasma Processes Conference (HTPP) Location: Brussels, BELGIUM Date: JUN 27-JUL 02, 2010 JOURNAL OF PHYSICS D-APPLIED PHYSICS Volume: 44 Issue: 19 Article Number: 194010 Published: MAY 18 2011	0	2	1	3	0	6	1.20

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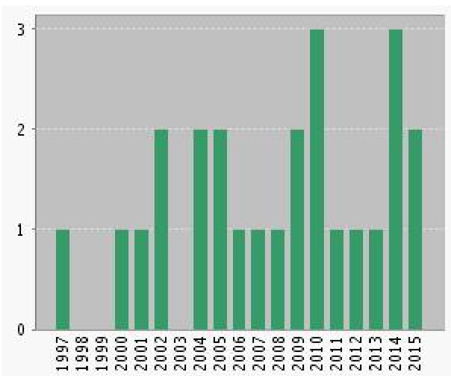

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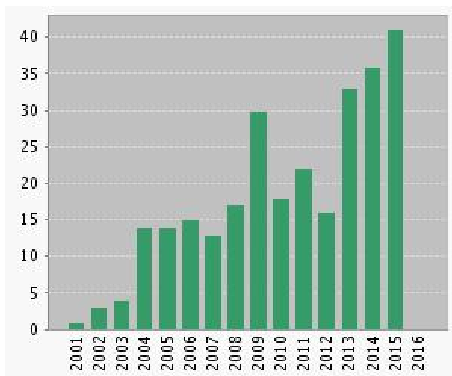

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	2012	2013	2014	2015	2016	Total	Average Citations per Year
Use the checkboxes to remove individual items from this Citation Report or restrict to items published between 1980 and 2016 Go	16	33	36	41	0	277	18.47
11. **Optical emission spectroscopy for simultaneous measurement of plasma electron density and temperature in a low-pressure microwave induced plasma** By: Konjevic, N.; Jovicevic, S.; Ivkovic, M. PHYSICS OF PLASMAS Volume: 16 Issue: 10 Article Number: 103501 Published: OCT 2009	2	2	0	0	0	6	0.86
12. **On the Stark broadening of Ne I lines and quasi-static versus ion impact approximation** By: Jovicevic, S; Ivkovic, M; Zikic, R; et al. JOURNAL OF PHYSICS B-ATOMIC MOLECULAR AND OPTICAL PHYSICS Volume: 38 Issue: 8 Pages: 1249-1259 Published: APR 28 2005	0	0	0	0	0	5	0.45
13. **On simultaneous determination of electron impact width, ion-broadening and ion-dynamic parameter from the shape of plasma broadened non-hydrogenic atom line** By: Ivkovic, M.; Zikic, R.; Jovicevic, S.; et al. JOURNAL OF PHYSICS B-ATOMIC MOLECULAR AND OPTICAL PHYSICS Volume: 39 Issue: 7 Pages: 1773-1785 Published: APR 14 2006	0	0	0	0	0	4	0.40

14. **Hydrogen Balmer beta: The separation between line peaks**

	for plasma electron density diagnostics and self-absorption test By: Ivkovic, Milivoje; Konjevic, Nikola; Pavlovic, Zoran JOURNAL OF QUANTITATIVE SPECTROSCOPY & RADIATIVE TRANSFER Volume: 154 Pages: 1-8 Published: MAR 2015	0	0	0	3	0	3	3.00
15.	**Stark broadening of 3s (3)P(0)-3p (3)D and 3p (3)D-3d (3)F(0) transitions along carbon isoelectronic sequences of ions revisited** By: Ivkovic, M; Ben Nessib, N; Konjevic, N JOURNAL OF PHYSICS B-ATOMIC MOLECULAR AND OPTICAL PHYSICS Volume: 38 Issue: 6 Pages: 715-728 Published: MAR 28 2005	0	0	0	0	0	3	0.27
16.	**Stark broadening of the He I 492.2 nm line with forbidden components in dense low-temperature plasma** By: Ivkovic, M.; Gonzalez, M. A.; Lara, N.; et al. JOURNAL OF QUANTITATIVE SPECTROSCOPY & RADIATIVE TRANSFER Volume: 127 Pages: 82-89 Published: SEP 2013	0	0	1	1	0	2	0.67
17.	**Development and Testing of a Self-Triggered Spark Reactor for Plasma Driven Dry Reforming of Methane** By: Shapoval, Volodymyr; Marotta, Ester; Ceretta, Claudio; et al. PLASMA PROCESSES AND POLYMERS Volume: 11 Issue: 8 Pages: 787-797 Published: AUG 2014	0	0	0	1	0	1	0.50
18.	**Industrial CO2 laser system for nonmetal processing** By: Ivkovic, M; Jovicevic, S; Konjevic, N Edited by: Koicki, S; Knojevic, N; Petrovic, ZL; et al. Conference: Conference on Applied Physics in Serbia Location: BELGRADE, YUGOSLAVIA Date: MAY 27-29, 2002 Sponsor(s): Serbian Acad Sci & Arts; Minist Sci Technol & Dev Republ Serbia; Minist Dev Sci & Environ Fed Republ Yugoslavia; NIS Rafinerija Nafte Beograd; Kryooprema Belgrade APPLIED PHYSICS IN SERBIA-APS Pages: 187-190 Published: 2002	0	0	0	0	0	1	0.07
19.	**The discharge for plasma Stark shift measurement and results for He I 706.522 nm line** By: Ivkovic, M.; Gajo, T.; Savic, I.; et al. JOURNAL OF QUANTITATIVE SPECTROSCOPY & RADIATIVE TRANSFER Volume: 161 Pages: 197-202 Published: AUG 2015	0	0	0	0	0	0	0.00
20.	**Spatial and Temporal Characteristics of Laser Ablation Combined With Fast Pulse Discharge** By: Vinic, Milica; Ivkovic, Milivoje IEEE TRANSACTIONS ON PLASMA SCIENCE Volume: 42 Issue: 10 Special Issue: SI Pages: 2598-2599 Part: 1 Published: OCT 2014	0	0	0	0	0	0	0.00

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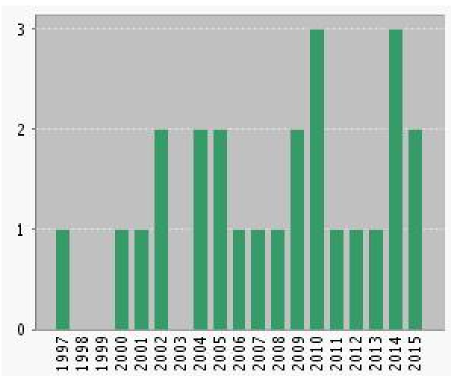

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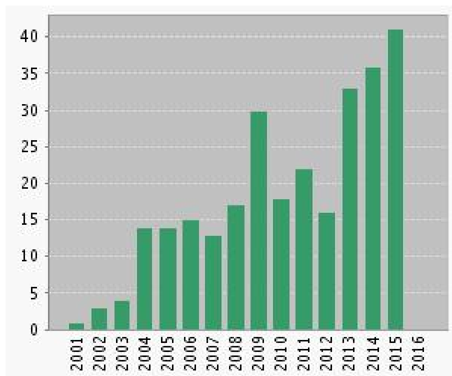

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	2012	2013	2014	2015	2016	Total	Average Citations per Year
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21. **Laser ablation initiated fast discharge for spectrochemical applications** By: Vinic, Milica L.; Ivkovic, Milivoje R. HEMIJSKA INDUSTRIJA Volume: 68 Issue: 3 Pages: 381-388 Published: MAY-JUN 2014	0	0	0	0	0	0	0.00
22. **PS-NH2 + PMMA-COOH blend: A promising substrate material for the deposition of densely packed gold nanoparticles** By: Bozanic, D. K.; Ivkovic, M.; Bibic, N.; et al. PHYSICA STATUS SOLIDI-RAPID RESEARCH LETTERS Volume: 4 Issue: 3-4 Pages: 85-87 Published: APR 2010	0	0	0	0	0	0	0.00
23. **Separation between Allowed and Forbidden Component of the He I 447 nm Line in High Electron Density Plasma** By: Ivkovic, M.; Gonzalez, M. A.; Jovicevic, S.; et al. Edited by: Gigosos, MA; Gonzalez, MA Conference: 19th International Conference on Spectral Line Shapes Location: Valladolid, SPAIN Date: JUN 15-20, 2008 Sponsor(s): Junta Castilla Leon; Minist Educ & Ciencia; Consejo Super Invest Cient; Minist Asunto Exter; Ctr Invest Energet Medioambiental; Fund Univ Castill Leon; Univ Vallladolid; Ayuntamiento Valladolid; Oficina Congres Valladolid SPECTRAL LINE SHAPES VOL 15 Book Series: AIP Conference Proceedings Volume: 1058 Pages: 66-68 Published: 2008	0	0	0	0	0	0	0.00

24.	**LOW-ELECTRON DENSITY PLASMA DIAGNOSTICS BY OPTICAL EMISSION TECHNIQUE** By: Konjevic, N.; Ivkovic, M.; Jovicevic, S. Edited by: Aubrecht, V; Bartlova, M Conference: 17th Symposium on Physics of Switching Arc Location: Brno, CZECH REPUBLIC Date: SEP 10-13, 2007 Sponsor(s): OEZ Letohrad; Siemens sro; Minist Educ, Youth & Sports; Labimex sro; Brno Univ Technol, Dept Phys; Brno Univ, Dept Power Elect & Elect Engn XVIITH SYMPOSIUM ON PHYSICS OF SWITCHING ARC, VOL II: INVITED PAPERS Pages: 27-36 Published: 2007	0	0	0	0	0	0	0.00
25.	**Laser damage in ferrites of MnZn spinels and other possible interactions** By: Sreckovic, M; SijackiZeravcic, V; Ivanovic, N; et al. OPTICS AND LASERS IN ENGINEERING Volume: 27 Issue: 5 Pages: 507-522 Published: 1997	0	0	0	0	0	0	0.00

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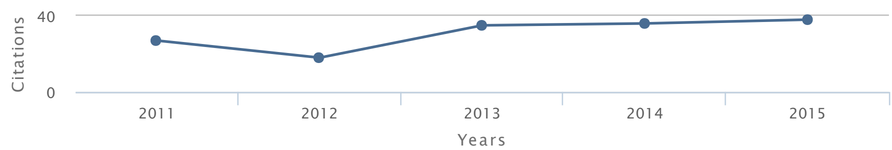

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1 The discharge for plasma Stark shift measurement and results...	2015							0		0
2 Hydrogen Balmer beta: The separation between line peaks for ...	2015						2	2		2
3 Spatial and temporal characteristics of laser ablation combi...	2014							0		0
4 Development and testing of a self-triggered spark reactor fo...	2014						1	1		1
5 Laser ablation initiated fast discharge for spectrochemical ...	2014							0		0
6 Stark broadening of the He I 492.2nm line with forbidden com...	2013					2	1	3		3
7 Hydrogen Balmer lines for low electron number density plasma...	2012				7	12	12	31		31
8 Research areas of the Plasma Spectroscopy Group at the Unive...	2011							0		0
9 Plasma diagnostics using the He i 447.1 nm line at high and ...	2011				2	1	1	4		4
10 Spectroscopic diagnostics of laser-induced plasmas	2010		6	3	11	8	5	33	1	34
11 Stark broadening of the hydrogen Hy spectral line at moderat...	2010							0		0
12 PS-NH2 + PMMA-COOH blend: A promising substrate material for...	2010							0		0
13 A simple line shape technique for electron number density di...	2010		5	3	3	2	3	16		16
14 Optical emission spectroscopy for simultaneous measurement o...	2009	1	1	2	1			4		5
15 Spectroscopic study of hydrogen Balmer lines in a microwave-...	2009	6				1		1		7
16 Separation between allowed and forbidden component of the he...	2008							0		0
17 Low-electron density plasma diagnostics by optical emission ...	2007			1				1		1
18 Optical emission spectroscopic techniques for low electron d...	2006							0		0
19 On simultaneous determination of electron impact width, ion-...	2006	3	1					1		4
20 On the Stark broadening of Ne i lines and quasi-static versu...	2005	5						0		5
21 Stark broadening of 3s3P0-3p 3D and 3p3D-3d 3F0 transitions ...	2005	4						0		4
22 Low electron density diagnostics: Development of optical emi...	2004	31	8	3	6	3	5	25		56
23 Excessive Balmer line broadening in microwave-induced discha...	2004	22		1	1			2		24
24 A program for the evaluation of electron number density from ...	2002	27	1	3	4	4	4	16		43
25 Parametric study of an atmospheric pressure microwave-induce...	2001	9				1		1		10
26 Parametric study of an atmospheric pressure microwave-induce...	2000	22	3	1		1	2	7		29
27 Laser damage in ferrites of MnZn spinels and other possible ...	1997							0		0
28 Transitions between glow and arc modes and its influences to...	1995							0		0
29 Influence of ion dynamics on the width and shift of isolated...	1995	18	2	1		1	2	6		24

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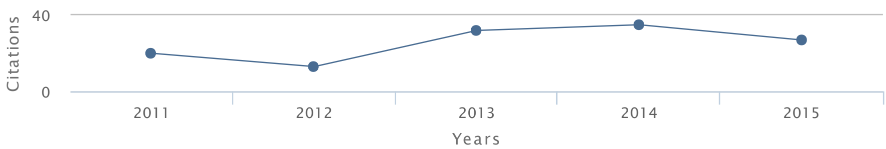

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6	Stark broadening of the He I 492.2nm line with forbidden com...	2013					2		2		2
7	Hydrogen Balmer lines for low electron number density plasma...	2012				7	11	11	29		29
8	Research areas of the Plasma Spectroscopy Group at the Unive...	2011							0		0
9	Plasma diagnostics using the He i 447.1 nm line at high and ...	2011				1	1		2		2
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11	Stark broadening of the hydrogen Hγ spectral line at moderat...	2010							0		0
12	PS-NH2 + PMMA-COOH blend: A promising substrate material for...	2010							0		0
13	A simple line shape technique for electron number density di...	2010		3	3	2	2	1	11		11
14	Optical emission spectroscopy for simultaneous measurement o...	2009	1	1	1	1			3		4
15	Spectroscopic study of hydrogen Balmer lines in a microwave-...	2009	5				1		1		6
16	Separation between allowed and forbidden component of the he...	2008							0		0
17	Low-electron density plasma diagnostics by optical emission ...	2007							0		0
18	Optical emission spectroscopic techniques for low electron d...	2006							0		0
19	On simultaneous determination of electron impact width, ion-...	2006	1	1					1		2
20	On the Stark broadening of Ne i lines and quasi-static versu...	2005	2						0		2
21	Stark broadening of 3s3P0-3p 3D and 3p3D-3d 3F0 transitions ...	2005	3						0		3
22	Low electron density diagnostics: Development of optical emi...	2004	26	7	2	6	3	4	22		48
23	Excessive Balmer line broadening in microwave-induced discha...	2004	21		1	1			2		23
24	A program for the evaluation of electron number density from...	2002	24		2	4	4	3	13		37
25	Parametric study of an atmospheric pressure microwave-induce...	2001	7				1		1		8
26	Parametric study of an atmospheric pressure microwave-induce...	2000	18	2	1		1	1	5		23
27	Laser damage in ferrites of MnZn spinels and other possible ...	1997							0		0
28	Transitions between glow and arc modes and its influences to...	1995							0		0
29	Influence of ion dynamics on the width and shift of isolated...	1995	15	1	1		1	1	4		19

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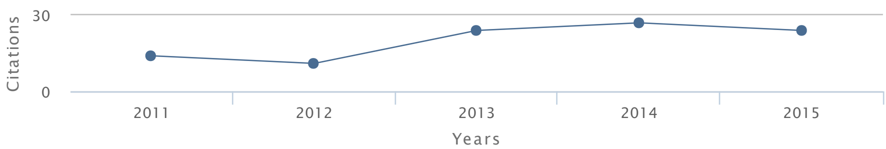

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#	Document	Year	<2011	2011	2012	2013	2014	2015	Subtotal	>2015	Total
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3	Spatial and temporal characteristics of laser ablation combi...	2014							**0**		0
4	Development and testing of a self-triggered spark reactor fo...	2014							**0**		0
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8	Research areas of the Plasma Spectroscopy Group at the Unive...	2011							**0**		0
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10	Spectroscopic diagnostics of laser-induced plasmas	2010		3	2	9	7	4	**25**	1	**26**
11	Stark broadening of the hydrogen Hγ spectral line at moderat...	2010							**0**		0
12	PS-NH2 + PMMA-COOH blend: A promising substrate material for...	2010							**0**		0
13	A simple line shape technique for electron number density di...	2010		3	2				**5**		**5**
14	Optical emission spectroscopy for simultaneous measurement o...	2009	1		1				**1**		**2**
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17	Low-electron density plasma diagnostics by optical emission ...	2007							**0**		0
18	Optical emission spectroscopic techniques for low electron d...	2006							**0**		0
19	On simultaneous determination of electron impact width, ion-...	2006	1	1					**1**		**2**
20	On the Stark broadening of Ne i lines and quasi-static versu...	2005	2						**0**		**2**
21	Stark broadening of 3s3P0-3p 3D and 3p3D-3d 3F0 transitions ...	2005	3						**0**		**3**
22	Low electron density diagnostics: Development of optical emi...	2004	24	4	2	5	3	4	**18**		**42**
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24	A program for the evaluation of electron number density from...	2002	19		1	4	4	2	**11**		**30**
25	Parametric study of an atmospheric pressure microwave-induce...	2001	6				1		**1**		**7**
26	Parametric study of an atmospheric pressure microwave-induce...	2000	17	2	1		1	1	**5**		**22**
27	Laser damage in ferrites of MnZn spinels and other possible ...	1997							**0**		0
28	Transitions between glow and arc modes and its influences to...	1995							**0**		0
29	Influence of ion dynamics on the width and shift of isolated...	1995	12	1	1			1	**3**		**15**

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ПРИЛОЗИ

1) Потврде о номинацијама за рад године.
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3) Доказ о чланству у Научном комитету и председавању секцијом SPIG-a.
4) Докази о рецензијама у часописима.
5) Подаци о учешћу на пројектима САНУ.
6) Потврде о менторству за Гајо.
7) Потврде о менторству за Драгојловић, Винић, Недановска, Коралт.
8) Програм курса *Технологија гасних ласера.*
9) Сагласност за предавања *Оптички и оптометријски инструменти.*
10) Сагласност за учешће на шпанском пројекту.
11) Уговор о пројекту сарадње са Румунијом.
12) Уговор о пројекту Павле Савић са ЛПЗ из Марсеја.
13) Подаци о ФП7 пројекту – BIOPOLNANOTECH.
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Editorial

Elsevier/Spectrochimica Acta Atomic Spectroscopy Award 2010

This is to announce the 2010 Elsevier/Spectrochimica Acta Award, the annual award honoring the most significant article(s) published in a volume. Elsevier makes this award on behalf of Spectrochimica Acta, Part B, to encourage the publication of top articles in this journal. All papers published during one year are considered for this award and the Editorial Advisory Board and the Guest Editor(s) of the special issues are responsible for the selection. The award consists of a monetary prize of $1000 together with a presentation certificate.

We have the pleasure to announce the 2010 Award for the articles published in Spectrochimica Acta Part B, Volume 65. The votes of the jury accumulated for a paper discussing critically the statements commonly made in the literature regarding the existence of local thermodynamic equilibrium in laser-induced plasmas. The paper pointed out the main criteria to be fulfilled to validate this assumption and concluded that the mere use of the McWhirter criterion should be discontinued. The work resulted from collaboration between the CNR of Pisa (Italy), the University of Bari (Italy), the CNR-IMIP of Bari (Italy) and the University of Florida, Gainesville (USA).

The paper selected for the Award is the following:

G. Cristoforetti, A. De Giacomo, M. Dell'Aglio, S. Legnaioli, E. Tognoni, V. Palleschi, N. Omenetto
Views and Criticism: Local Thermodynamic Equilibrium in Laser-Induced Breakdown Spectroscopy: Beyond the McWhirter criterion.
Spectrochim. Acta Part B 65 (2010) 86–95.

Three other papers closely followed the above paper. These papers deal with calibration in atomic spectrometry, a topic of essential analytical relevance for all atomic spectroscopic techniques, one paper on imaging of aerosols particles formed by laser ablation and one paper on the mechanism of plasma formation after resonance laser excitation of cesium vapors.

These papers are:

J.M. Mermet
Review: Calibration in atomic spectrometry: A tutorial review dealing with quality criteria, weighting procedures and possible curvatures.
Spectrochim. Acta Part B 65 (2010) 509–523.

J. Koch, S. Heiroth, T. Lippert, D. Günther
Femtosecond laser ablation: Visualization of the aerosol formation process by light scattering and shadowgraphic imaging.
Spectrochim. Acta Part B 65 (2010) 943–949.

C. Vadla, V. Horvatic, D. Veza, K. Niemax
Resonantly laser-induced plasmas in gases: The role of energy pooling and exothermic collisions in plasma breakdown and heating.
Spectrochim. Acta Part B 65 (2010) 33–45.

As usual, since the introduction of the award, many other papers scored high on the jury's list. For the 2010 volume, this list, in alphabetical order of the first authors, looks as follows:

A. D'Ulivo
Review: Mechanism of generation of volatile species by aqueous boranes: Towards the clarification of most controversial aspects.
Spectrochim. Acta Part B 65 (2010) 360–375.

A. De Giacomo, R. Gaudiuso, M. Dell'Aglio, A. Santagata
The role of continuum radiation in laser-induced plasma spectroscopy.
Spectrochim. Acta Part B 65 (2010) 385–394.

R. Glaus, R. Kaegi, F. Krumeich, D. Günther
Phenomenological studies on structure and elemental composition of nanosecond and femtosecond laser-generated aerosols with implications on laser ablation inductively coupled plasma spectrometry.
Spectrochim. Acta Part B 65 (2010) 812–822.

M. Grotti, J.L. Todolí, J.-M. Mermet
Influence of the operating parameters and of the sample introduction system on time correlation of line intensities using an axially viewed, CCD-based inductively coupled plasma optical emission spectroscopy system.
Spectrochim. Acta Part B 65 (2010) 137–146.

M. Ivković, M.A. Gonzalez, S. Jovićević, M.A. Gigosos, N. Konjević
A simple line shape technique for electron number density diagnostics of helium and helium-seeded plasmas.
Spectrochim. Acta Part B 65 (2010) 234–240.

M. Ribière, B.G. Chéron
Analysis of relaxing laser-induced plasmas by absorption spectroscopy: Toward a new quantitative diagnostic technique.
Spectrochim. Acta Part B 65 (2010) 524–532.

C.M. Sparks, U.E.A. Fittschen, G.J. Havrilla
Picoliter solution deposition for total reflection X-ray fluorescence analysis of semiconductor samples.
Spectrochim. Acta Part B 65 (2010) 805–811.

0584-8547/$ – see front matter
doi:10.1016/j.sab.2012.01.006

E. Tognoni, G. Cristoforetti, S. Legnaioli, V. Palleschi
Review: Calibration-free laser-induced breakdown spectroscopy: State of the art.
Spectrochim. Acta Part B 65 (2010) 1–14.

T. Tomie
The birth of the X-ray refractive lens.
Spectrochim. Acta Part B 65 (2010) 192–198.

The editors note that the paper chosen for the award belongs to the category *Views and Criticism*, indicating the usefulness of this section of our journal. We would therefore like to draw the authors' attention to the opportunity of using this forum of scientific debate on topics of spectrochemical interest. Moreover, three other *Review* papers have been nominated and received high scores: this is gratifying for our reviews editors and their efforts, which we gratefully acknowledge. Finally, we point out that X-ray papers, which play a relevant part among those submitted to the journal, have also been considered as candidates for the award.

As in the past, the task of choosing the most significant contribution from the annual publications was difficult, demonstrating once again the high standard of Spectrochimica Acta Part B. We thank the authors, the reviewers and the advisory board for their continuous support.

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Greet de Loos

Spectrochimica Acta Part B 93 (2014) iv–v

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Editorial

Elsevier/Spectrochimica Acta Atomic Spectroscopy Award 2012

This is to announce the 2012 Elsevier/Spectrochimica Acta Award, the annual award honoring the most significant article(s) published in a volume. Elsevier makes this award on behalf of Spectrochimica Acta, Part B, to encourage the publication of top articles in this journal. All papers published during one year are considered for this award and the Editorial Advisory Board and the Guest Editor(s) of the special issue(s) are responsible for the selection. The award consists of a monetary prize of $1000 together with a presentation certificate.

We have the pleasure to announce the 2012 Award for the articles published in Spectrochimica Acta Part B, Volumes 67–78. This year, the jury nominated 29 papers and the choice of the best paper has been very difficult: in fact, eight papers have been competing for the award until the last few votes.

A study by the group of Niemax, dealing with the investigation of matrix effects in the inductively coupled plasma by the introduction of single droplets, accumulated the highest score and was therefore selected for the award. The work was carried out in Dortmund (Leibnitz-Institute for Analytical Sciences — ISAS) and in Berlin (Federal Institute for Materials Research and Testing — BAM). We note that another article from the same group had already been selected for the 2009 award, thus testifying the importance of this research topic. The title of the paper is:

A. Murtazin, S. Groh and K. Niemax
Investigation of sample introduction- and plasma-related matrix effects in inductively coupled plasma spectrometry applying single analyte droplet and particle injection
Spectrochim. Acta Part B 67 (2012) 3–16.

Seven other papers scored closely to the above paper. A group of three papers from Houk's group at Iowa State University (Ames, Iowa) deal with fundamental studies of the origin and behavior of polyatomic ions in laser ablation-inductively coupled plasma mass spectrometry. One paper from the Farnsworth's group at Brigham Young University (Provo, Utah) characterizes the effect of the skimmer cone design on ion transmission efficiency. Two papers resulting from the collaboration of the group in Lyon (University of Lyon 1, Villeurbanne, France) with several other French institutions describe a dual-wavelength differential imaging approach to plasma diagnostics as well as an attempt to correlate native bonds in polymeric materials with molecular emissions. The final paper, dealing with confocal nano-X-ray fluorescence analysis, is the result of a collaboration between the Ghent University (Ghent, Belgium), the Goethe University Frankfurt (Germany) and ESRF Grenoble Cedex, France.

The above papers are listed below:

T.M. Witte and R.S. Houk
Origin of polyatomic ions in laser ablation-inductively coupled plasma mass spectrometry: An examination of metal oxide ions and effects of nitrogen and helium in the aerosol gas flow
Spectrochim. Acta Part B 76 (2012) 9–19.

C.H. Ebert, T.M. Witte and R.S. Houk
Investigation into the behavior of metal–argon polyatomic ions (MAr^+) in the extraction region of inductively coupled plasma-mass spectrometry
Spectrochim. Acta Part B 76 (2012) 119–125.

T.M. Witte and R.S. Houk
Metal argide (MAr^+) ions are lost during ion extraction in laser ablation-inductively coupled plasma mass spectrometry
Spectrochim. Acta Part B 76 (2012) 25–31.

N. Taylor and P.B. Farnsworth
Experimental characterization of the effect of the skimmer cone design on shock formation and ion transmission efficiency in the vacuum interface of an inductively coupled plasma mass spectrometer
Spectrochim. Acta Part B 69 (2012) 2–8.

V. Motto-Ros, Q.L. Ma, S. Grégoire, W.Q. Lei, X.C. Wang, F. Pelascini, F. Surma, V. Detalle and J. Yu
Dual-wavelength differential spectroscopic imaging for diagnostics of laser-induced plasma
Spectrochim. Acta Part B 74–75 (2012) 11–17.

S. Grégoire, V. Motto-Ros, Q.L. Ma, W.Q. Lei, X.C. Wang, F. Pelascini, F. Surma, V. Detalle and J. Yu
Correlation between native bonds in a polymeric material and molecular emissions from the laser-induced plasma observed with space and time resolved imaging
Spectrochim. Acta Part B 74–75 (2012) 31–37.

T. Schoonjans, G. Siversmit, B. Vekemans, S. Schmitz, M. Burghammer, C. Riekel, F.E. Brenker and L. Vincze
Fundamental parameter-based quantification algorithm for confocal nano-X-ray fluorescence analysis
Spectrochim. Acta Part B 67 (2012) 32–42.

http://dx.doi.org/10.1016/j.sab.2014.02.004

Finally, we report the other papers scoring high on the jury's list. For the 2012 volume, this list, in alphabetical order of the first authors, looks as follows:

L.M. Cabalín, A. González, V. Lazic and J.J. Laserna
Laser-induced breakdown spectroscopy of metals covered by water droplets
Spectrochim. Acta Part B 74–75 (2012) 95–102.

N. Konjević, M. Ivković and N. Sakan
Review: Hydrogen Balmer lines for low electron number density plasma diagnostics
Spectrochim. Acta Part B 76 (2012) 16–26.

K. Niemax
Considerations about the detection efficiency in inductively coupled plasma mass spectrometry
Spectrochim. Acta Part B 76 (2012) 65–69.

B. Pokrzywka A. Mendys, K. Dzierżęga, M. Grabiec and S. Pellerin
Laser light scattering in a laser-induced argon plasma: Investigations of the shock wave
Spectrochim. Acta Part B 74–75 (2012) 24–30.

As in the past, the papers selected focus on the fundamental aspect of spectroscopic techniques, thus maintaining the fingerprint of the journal. We thank the authors, the reviewers and the advisory board for their continuous support.

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ПУБЛИКАЦИЈЕ АСТРОНОМСКЕ ОПСЕРВАТОРИЈЕ У БЕОГРАДУ
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Св. 74 No. 74

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PARAMETRIC STUDY OF AN ATMOSPHERIC PRESSURE MICROWAVE INDUCED PLASMA OF THE MINI MIP TORCH

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Abstract. The results of spatial distribution measurements of the electron number density, excitation and rotationl temperatures in an atmospheric pressure microwave induced plasma in argon are presented. Electron number density, n_e is determined from the width of the hydrogen H_β 486.13 nm line. The excitation temperature, T_{exc}, is determined from the Boltzmann plot of relative line intensities either of carrier gas argon or iron that is introduced in the form of aerosols. The rotational temperatures, T_{rot}, are determined from the relative intensities of OH (R_2 and Q_1 branch) electronic band $A^2\,\Sigma - X^2\,\Pi$ (0,0) and to N_2^+ first negative system $B^2\,\Sigma_u^+ - X^2\,\Sigma_g^+$ (P branch). The influence of the microwave input power in the range 80 W - 150 W on the spatial distribution of n_e, T_{exc} and T_{rot} is determined at first. For the selected input power of 100 W, the influence of molecular hydrogen in the wet and desolvated nebulizer and support gas and the corresponding changes in distributions are studied. The influence of potassium as a low ionization potential element on the spatial distribution of n_e, T_{exc} and T_{rot} is also studied.

1. INTRODUCTION

Microwave induced plasma (MIP) is widely used as a well-established spectrochemical excitation source. In most of the early works plasma is created in coaxial cavities and experiments performed in helium and argon at reduced pressures and in argon at atmospheric pressure. The important step forward in further analytical applications of MIPs came in 1976 when Beenakker [1] showed that with new type of TM_{010} microwave cavity it was possible to sustain the stable plasma in argon and helium at atmospheric pressure. This cavity was further improved [2-6] and applied to spectrochemical analysis as an emission source for the analysis of gases and solutions and especially as a gas chromatography atomic emission detector. The supercritical fluid chromatography [7] and MIP-mass spectrometry [8] employ successfully the TM_{010} cavity too.

The three comprehensive reviews covered a variety of MIP sources, numerous analytical applications and even perspectives of MIP applications [9-11]. The basic MIP properties like particle densities and temperatures are also reported in these reviews. According to analysis of the available atmospheric MIP data including those from [9-11] one can conclude that numerous results dealing with plasma parameters are published. One is missing however larger scale systematic studies where MIP parameters are simultaneously measured, their mutual dependence determined and analyzed. It is obvious that better understanding of physical processes in plasma source is of importance for analytical applications of MIPs. In order to improve this situation we started a parametric study of mini MIP torch.

2. EXPERIMENT

2.1. *Plasma source.* The plasma is generated in the resonant microwave cavity. We used commercially available Van Dalen et al. [2] modification of Beenakker [1] cylindrical resonant cavity supplied by microwave generator via coaxial cable.

The spatial plasma distortion which would appear if one uses the single discharge tube for analyte gas flow is eliminated by the use of Mini MIP Torch discharge tube system similar to the tangential flow MIP torch reported by Bollo-Kamará et al.[3]. Their torch, constructed entirely from quartz, utilizes a concentric tube arrangement with a thread insert to generate a tangential support gas flow. The thread is fused to the inner tube and then sealed to the outer one. The Mini-MIP-Torch also uses two concentric tubes, but made of Al oxide [4], separated by the cooper wire. These tubes (outer diameters 4 mm and 2 mm) are fixed by stainless steel body and holding nut via graphite gasket. The windings of the cooper wire are the same as the Bollo-Kamara [3] threaded insert. Analyte sample gas goes through the inner tube while the plasma support gas is introduced through the outer sleeve and exits from the cooper wire windings with a spiral trajectory. By increasing the flow rate of support gas (up to 500ml/min), the discharge starts to behave as a rod like filament suspended in the center of the discharge tube and extends outside the cavity. Once this so-called "suspended plasma" is formed the gas flow rate can be decreased to less than 0.3 l/min. The generated discharge is spatially and temporally stable and separated from the tube walls.

The analyte gas, wet or desolvated, is prepared in a system similar to the one described by Veillon et al. [12]. It consists of a right angle pneumatic nebulizer, spray chamber, evaporating chamber and modified Liebig-Graham condenser.

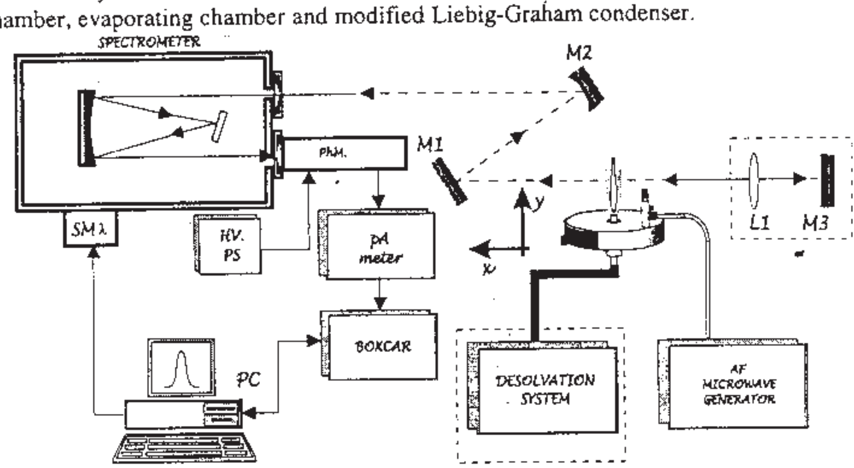

Figure 1. Schematic diagram of the experimental setup: **SMλ** – steping motor; **PhM** – photomultiplier tube; **HVPS** - high voltage power supply, $\mathbf{M_1}$ and $\mathbf{M_3}$ - plane mirrors; $\mathbf{M_2}$ - mirror focal length 50 cm; $\mathbf{L_1}$ - quartz lens, 8 cm focal length, diameter 2.5cm.

For the generation of aerosols from aqueous solution of analyzed samples Meinhard right angle pneumatic nebulizer is used. The aerosols generated by this nebulizer have extremely wide range of drop sizes and very turbulent gas flow patterns (Browner et all, [13]). In order to reduce consequent random fluctuations of spectral lines intensities dual Scott-type tube [14] spray chamber is used. The evaporation of water is achieved by the use of a glass chamber heated at the temperature of 300^0 C. This temperature is controlled by thermocouple and appropriate electronics. The water vapor is later condensed in the Liebich Graham condenser cooled with water at the temperature of 3^0 C. The water droplets are accumulated in the drain and the dry gas with analytic sample is introduced in the discharge tube.

2.2. *The experimental setup.*

By means of optical mirrors the 1:1 image of the plasma source is projected, see Fig 1, on the entrance slit (20 μm wide and 1 mm high) of the 0.5 m Ebert type spectrometer with the reciprocal dispersion of 1.6 nm/mm in the first order of diffraction grating. Plane mirror M_3 and the lens L_1 see Fig1, are used only when the optical thickness of the investigated line is checked. Spectra recordings were performed by the use of photomultiplier mounted on the exit slit of the spectrometer. The wavelength scanning was achieved by the stepping motor whose driver is controlled by PC. The spectral line shapes are recorded by the help of boxcar averager and the same PC. For the improvement of signal to noise ratio, the averaging of 10 signals at each wavelength step is used.

In order to scan the plasma image over the entrance slit of the spectrometer the microwave cavity with the torch is mounted on the PC controlled X-Y table with the micro step resolution of 1 μm quoted by the manufacturer. To determine the spatial distribution of light intensity all plasma observations are performed side-on, see Fig.1. The laterally measured intensities are converted into radial intensities by performing the Abel inversion. The fittings of recorded radial intensity profiles and Abel inversion are performed by the use of different kind of Jakobi polynomials of various degree [15].

3. EXPERIMENTAL RESULTS AND DISCUSSION

3.1. *Determination of electron number density, n_e*

For determination of the electron number density the method which is based on the measurement of the Stark broadening of hydrogen atomic line at λ= 486.13 nm is used. The shape of H_β profile has been experimentally measured and n_e was determined using well-tested approximate formula by Wiesse et al. [16] For each of tested cases the

$$n_e\left[\ cm^{-3}\right] = 10^{16} * \left(\frac{W_s}{4.74}\right)^{1.49}$$

spatial maps with 1071 line profiles are recorded.

where Ws is H_β Stark halfwidth at half maximum [0.1nm].

The experimental condition used in the spatial electron number density measurements are specified in Table 1. In such a way, the influence of water, desolvation, additional molecular hydrogen and potassium element of low ionization potential is investigated.

First set of experiments is devoted to the investigation of the influence of microwave power input in the range 80W – 150 W to the plasma stability and homogeneity of electron

Table 1. Experimental conditions

Gas flow in all cases : nebulizer gas – 20 cm^3/min; sample gas– 200 cm^3/min

	Nebulizer gas	Support gas	Gas condition
1	Ar + H_2O	Ar	Wet
2	(Ar + 2.7% H_2) + H_2O	Ar	Wet
3	Ar + H_2O	Ar + 2.7% H_2	Wet
4	Ar + 2.7% H_2	Ar + 2.7% H_2	Dry
5	Ar + 2.7% H_2	Ar	Dry
6	(Ar + 2.7% H_2) + H_2O	Ar	Desolvated
7	(Ar + 2.7% H_2) + H_2O	Ar + 2.7% H_2	Desolvated
8	Ar + (KCl + H_2O)*	Ar	Wet
10	(Ar + 2.7% H_2) + (KCl+H_2O)**	Ar	Desolvated

* water solution of KCl – 1, 2 and 4 mg/ml

** water solution of KCl – 1 and 2 mg/ml

density, n_e, distribution. For input powers of 80, 100 and 150 W the maximum n_e determined are 9.8E14, 8.7E14 and 1.45E15 cm^{-3}, respectively. The maximum value of n_e at 100 W is
lower than at 80 W, but in this case, a larger volume of the MIP has the high electron number density and the plasma is spatially more homogenous. For these, all future investigations were performed at an input power of 100 W.

It is also possible to notice that the spatial distributions of the total H_β line intensity do not show any resemblance with the distributions of n_e. This is an indication that non-equilibrium conditions prevail in the MIP. The same conclusion can be derived from all other spatial n_e distributions and the corresponding H_β line intensity recordings, (Fig 2a and Fig 2b).

In most of the experiments, the only source of hydrogen atoms used for n_e diagnostics was the presence of water vapor, but in experiments with dry and desolvated nebulizer gas, a mixture of 2.7% of molecular hydrogen and argon is used for the same purpose. These experiments enebled to determine the influence of molecular hydrogen on the MIP parameters.

The spatial distributions of n_e and H_β line intensity in the case of wet nebulizer argon-hydrogen mixture and pure argon as a support gas, shows that the addition of 2.7% of hydrogen to the nebulizer gas do no change essentially the maximum value of n_e.

The effect of H_2 on the MIP is more pronounced when the argon-hydrogen mixture

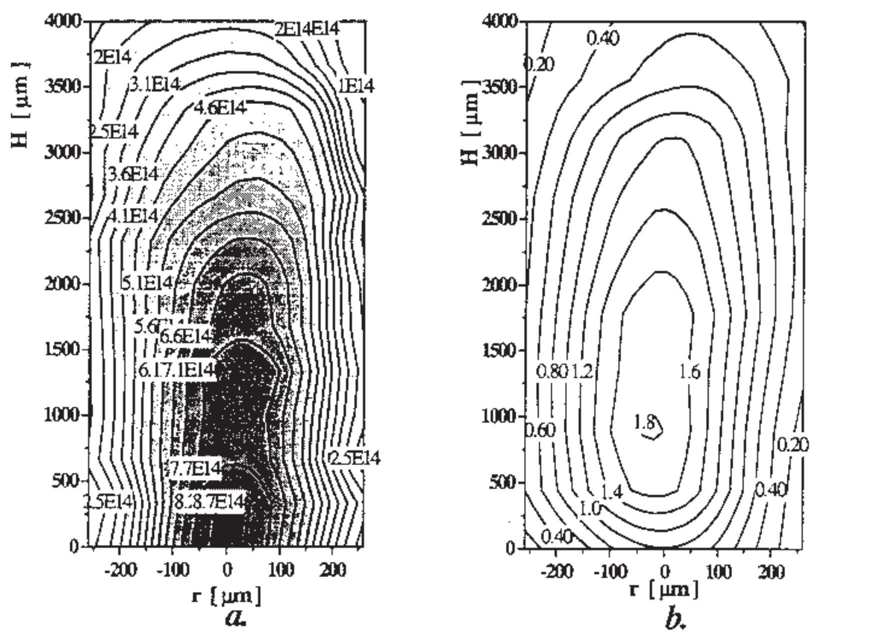

Figure 2. Spatial distribution of the electron number density *(a)* and distribution of integral H_β line intensity *(b)*, in arbitrary units. Conditions: wet argon as nebulizer gas and argon support gas; input power 100W.

being used as nebulizer gas is desolvated.The plasma volume and its shape are considerably changed while the maximum value of n_e decreases only by 15%. Similar differences in the values of n_e were reported in an ICP experiment [17], when wet and desolvated nebulizer gas was used.

If a dry Ar - H_2 mixture is used as a nebulizer gas, the maximum of n_e is decrease three times compared to the value obtained with desolvated nebulizer gas. This result suggests that the desolvated nebulizer gas still contains a large amount of water vapour which, through the process of dissociation and ionization, seems to be the main source of electrons.

Finally, if an Ar – H_2 mixture is used as a support gas with wet argon nebulizer gas, the maximum electron number density decreases by about 40% compared to the value observed when pure argon support gas is used. The role of molecular hydrogen regarding to the electron number density and MIP shape is most likely related to the

extremely large hydrogen thermal conductivity in the range of 2000 - 5000 K caused by dissociation of the H_2 molecule. As before, the large difference observed between the n_e and H_β maximum, indicates
strong non-equilibrium plasma conditions exist, (Fig 3a and Fig. 3b).

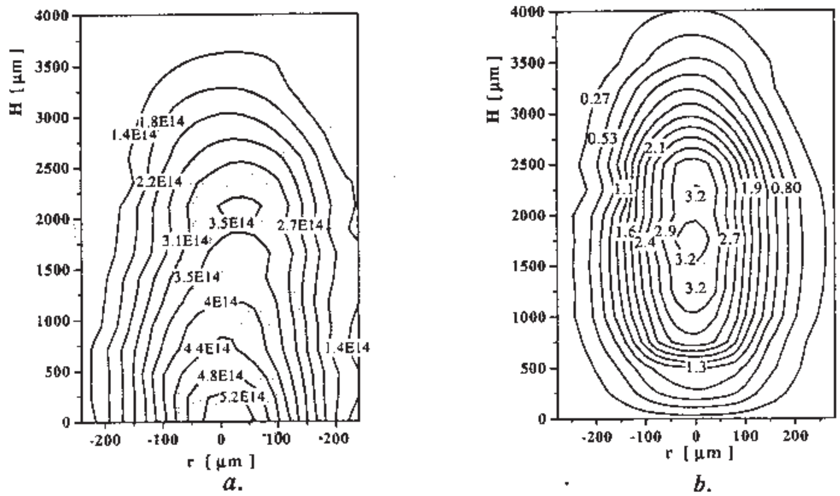

Figure 3. Spatial distribution of the electron number density *(a)* and distribution of integral H_β line intensity *(b)*, in arbitrary units. Conditions: wet argon as nebulizer gas and argon – hydrogen mixture support gas; input power 100W

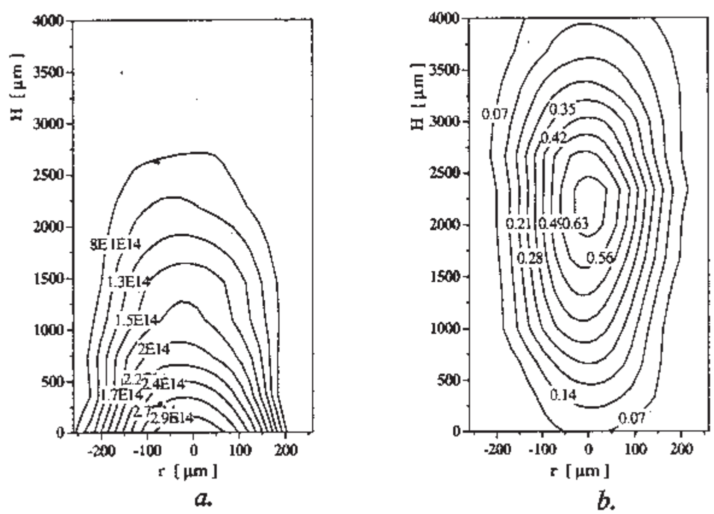

Figure 4. Spatial distribution of the electron number density *(a)* and distribution of integral H_β line intensity *(b)*, in arbitrary units. Conditions: argon with water solution of 2 mg/ml KCl as nebulizer gas and argon support gas; input power 100W.

The influence of an element characterized by a low ionization potential, such as potassium, on the distribution of n_e in the MIP is also studied. Potassium is introduced in the MIP in the form of a KCl aqueous solution. In the presence of 2 mg/ml of potassium in nebulizer gas, the electron number density decreases three times in comparison with wet argon. The maximums of n_e and H_β are shifted one from the other considerably, (Fig 4a and Fig. 4b).

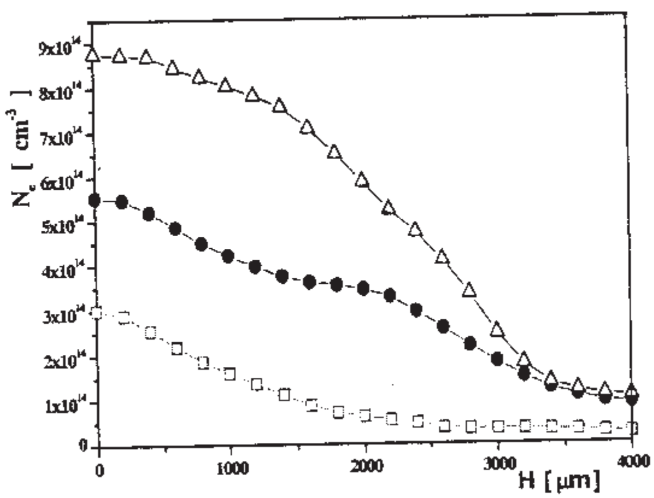

Figure 5. Axial distribution of the electron number density with nebulizer gas □:wet argon with argon as a support gas (Δ), wet argon with argon – hydrogen mixture as a support gas (•) and wet argon with

The study of the spatial distributions of n_e and H_β with desolvated nebulizer gas consisting of an argon-hydrogen mixture with 2 mg/ml of potassium, shows an interesting phenomenon. The MIP is divided along the axis into several regions with local maximum concentrations of n_e along the axis, while the maximum electron number density is further decreased by more than 50% in comparison with the previous case.

It is interesting to compare the axial distributions of n_e in the MIP observed with: (i.) wet argon with argon support gas, (ii.) wet nebulizer argon gas and $Ar - H_2$ support gas, and (iii.) wet argon with 2 mg/ml of KCl and argon support gas. This comparison can be seen in Fig. 5. The use of $Ar - H_2$ support gas decreases the maximum value of n_e and flattens its axial distribution. The effect of potassium in nebulizer gas is similar but more dominant.

3.2. *Determination of excitation temperature, T_{exc}.*

The excitation temperature, T_{exc}, is determined from the Boltzmann plot of relative line intensities either of carrier gas argon or iron that is introduced in the form of aerosols.

In order to obtain spatial distribution of T_{exc} from Ar I lines, see Table 2, line by line intensity distribution is first determined. In this way spatial maps with 1071 line intensities per line are recorded. The whole procedure is repeated for other seven Ar I lines and then from the Boltzmann plot T_{exc} is determined at each particular point. These temperatures are later used to determine spatial distribution of excitation temperatures. For selected experimental conditions it was possible to tests the influences of water, desolation, additional molecular hydrogen and potassium at T_{exc} distributions, (see Table 1.).

Table 2. Transition and atomic data of neutral argon and iron lines used for excitation temperature measurement [18, 19].

Emitter	Transition	λ [nm]	E_k [cm^{-1}]	g_k	A_{ki} [10^8 s^{-1}]
Ar I	4s[3/2]^0-5p[3/2]	415.859	117184	5	0.0140
	4s[3/2]^0-5p[5/2]	420.057	116943	7	0.00967
	4s[3/2]^0-5p[3/2]	427.217	117151	1	0.00797
	4s'[1/2]^0-5p'[3/2]	433.356	118469	5	0.00586
	4s'[1/2]^0-5p'[1/2]	433.534	118460	3	0.00387
	4s'[1/2]^0-4p'[1/2]	750.39	108723	1	0.445
	4s[3/2]^0-4p[3/2]	763.51	106238	5	0.245
	4s[3/2]^0-4p[5/2]	811.531	105436	7	0.331
Fe I	a ^{5}D - z ^{5}F^0	373.713	27167	9	0.142
	a ^{5}D - z ^{5}F^0	374.826	27560	5	0.0915
	a ^{5}F - y ^{5}F^0	374.948	34040	9	0.764
	a ^{5}F - y ^{5}F^0	375.823	34329	7	0.634
	a ^{5}F - y ^{5}F^0	376.379	34547	5	0.544

In the case when dry argon is used as well as nebulizer and support gas, see Fig 6a, large dip in the central region of T_{exc} spatial distribution of MIP may be noticed. The use of wet nebulizer gas instead of dry gas changes the axial T_{exc} distribution, see Fig 6b. This effect is easier to notice if one compares radial or axial T_{exc} distributions. It can bi noticed that the use of wet nebulizer gas instead of dry argon changes radial T_{exc} distribution into the bell shaped form, see Fig 7. The desolvation of wet nebulizer gas decreases, approximately 10%, maximum value of T_{exc}, but the shape of radial distribution remains similar. It is intersting to

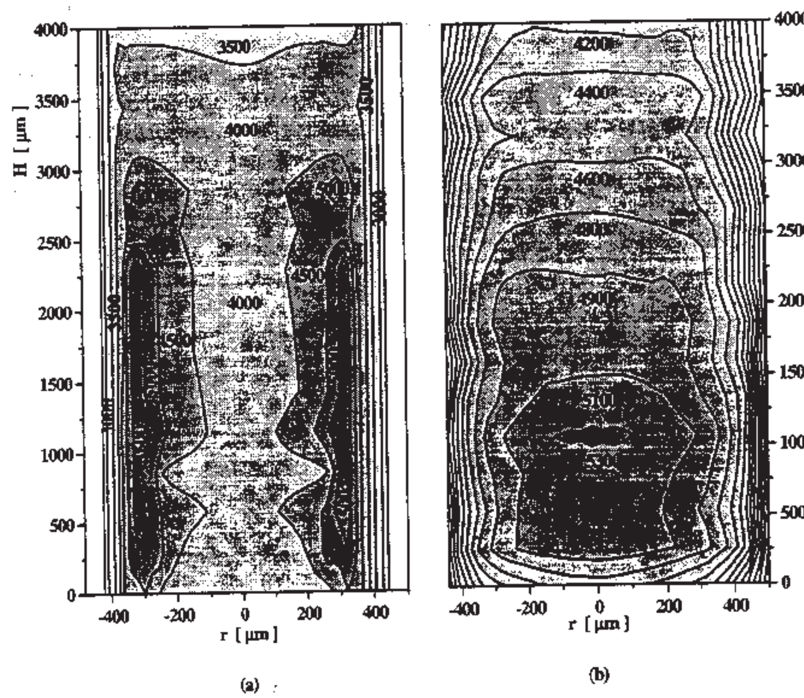

Figure 6. Spatial MIP T_{exc} distributions with a) dry argon nebulizer and support gas and b) wet argon nebulizer gas and dry argon support gas.

meation that under same conditios n_e is lower for 15%. The influence of the nebulizer gas desolvation is in qualitative agreement with the results of other researchers [20, 21, 22], and it is related to the presence of hydrogen and oxygen from the wet nebulizer gas.

Generally speaking, radial distributions of T_{exc} presented in Fig.7 are the best illustration of the influence of nebulizer and support gas variation to MIP excitation temperatures. Although these variations induce certain changes in axial direction, (see differences in Fig 7), the shape of radial distributions remains the same.

The addition of 2.7 % of hydrogen in argon support gas changes considerably radial distribution of the wet nebulizer gas with dry argon support gas from the bell shape to the one with the dip at the axis of MIP, see Fig 7. Under the same conditions this percentage of H_2 in support gas decreases axial n_e for about 40%

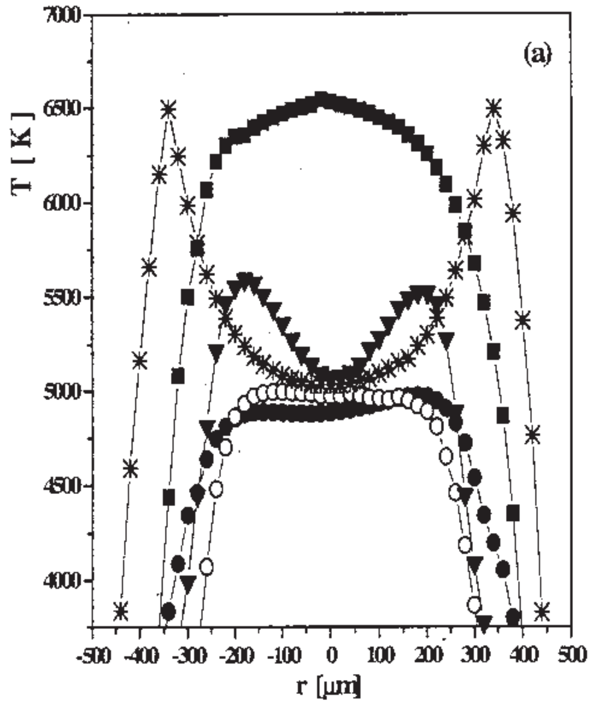

Figure 7. Radial distributions of T_{exc}; the axial position of 2000 μm from the torch orifice: (*) nebulizer gas dry Ar with support gas Ar, (H =1000μm); (○) nebulizer gas wet Ar with support gas dry Ar, (H = 1400μm); (●) nebulizer gas desolvated wet Ar with support gas dry Ar, (H = 2000μm); (▼) nebulizer gas wet Ar with support dry gas (Ar + 2.7% H_2), (H = 1800μm); (■) nebulizer gas KCl in wet Ar with dry support gas Ar, (H = 2000μm).

The influence of 2.7% of H_2 in argon support and dry argon nebulizer gas is shown in Fig.7. Like in the wet nebulizer gas where hydrogen is present as a result of water

dissociation, dip in T_{exc} is changing shape towards the bell shape distribution but the hydrogen concentration in support gas is not large enough to the change shape completely.

It comes out from the results and above discussion that small amount of water vapor and molecular hydrogen in MIP induces large change of plasma parameters. This is in qualitative agreement with [23] where detailed study of the influence of molecular gases to the intensity of analyte line.

The most dramatic change comes as a consequence of KCl presence in the nebulizer gas. Temperature increases considerably while the radial distribution has a bell shaped form.

Under same conditions n_e decreases three-fold in comparison with wet argon (compare Fig 4. and Fig.2).

The very same procedure is used for T_{exc} measurements from Fe I lines, (Table 2). The radial distribution of iron line intensities and determination of T_{exc} are performed only at 2000 μm from the torch orifice. At the same position radial T_{exc} distribution in the presence of wet KCl are performed too.

Radial distributions of excitation temperatures, T_{exc}, determined from Fe I and Ar I lines under the same experimental conditions, are given together for comparison in Fig. 8. Temperatures obtained from Ar I lines are slightly higher. The addition of KCl increases T_{exc} but not as much as T_{exc} obtained from argon lines, (see Fig.3).

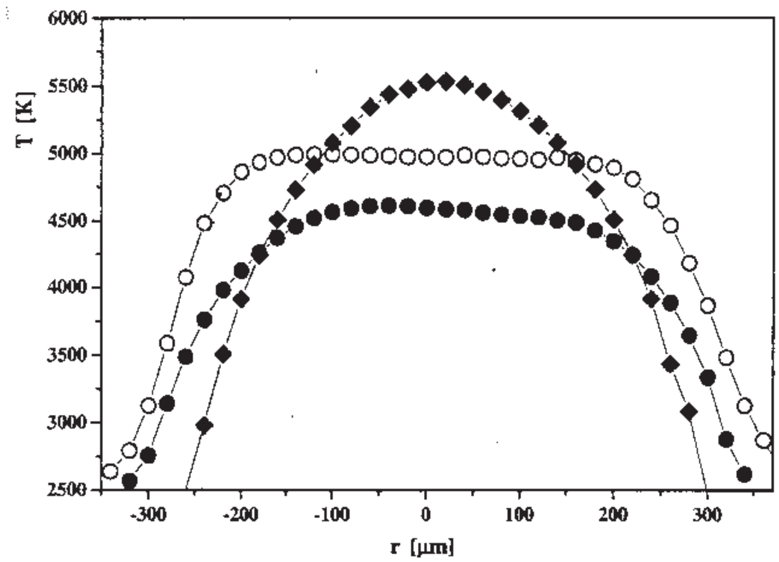

Figure 8. Radial distributions of T_{exc} at the axial position of 2000 μm from the torch orifice determined from: (○) Ar I lines; (●) Fe I lines; (■) Fe I lines in the presence of KCl in a nebulizer gas.

3.3. Determination of rotational temperatures, $T_{rot.}$

The rotational temperature, T_{rot}, is determined from the Boltzmann plot of relative intensities rottional lines of first negative system of nitrogen molecul ion N_2^+ and of OH radical. The radial distribution of rottional lines intensities and determination of T_{rot} are performed only at 2000 μm from the torch orifice. Same procedure of data proccessing as in the case of excitation temperature detrmination are performed. This procedure consists of Abel inversion procedure.

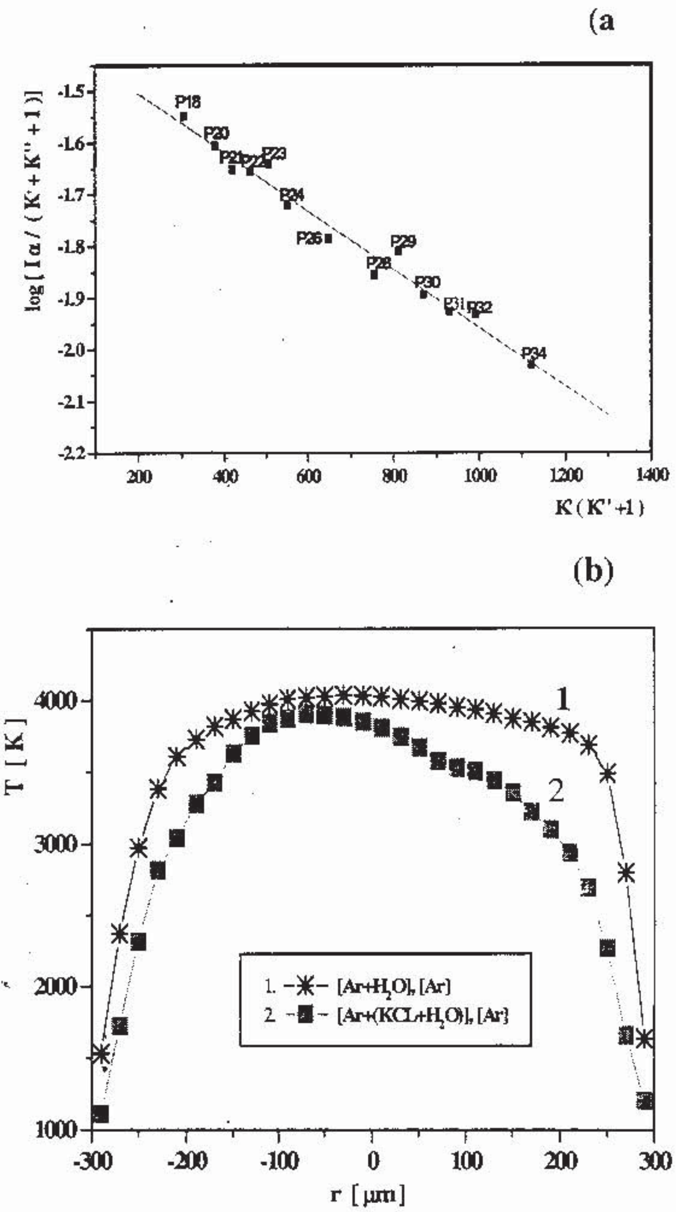

Figure 9. (a) Typical Boltzmann plot at r = 0, i.e. discharge center and H = 2000 μm; (b) Radial distributions of T_{rot} at the axial position of 2000 μm from the torch orifice determined from P- branch of first negative

As first step of rotational temperature detrmination very carefull identification of spectra must be performed or great mistakes can be produced, [24, 25]. This is not a simple task.

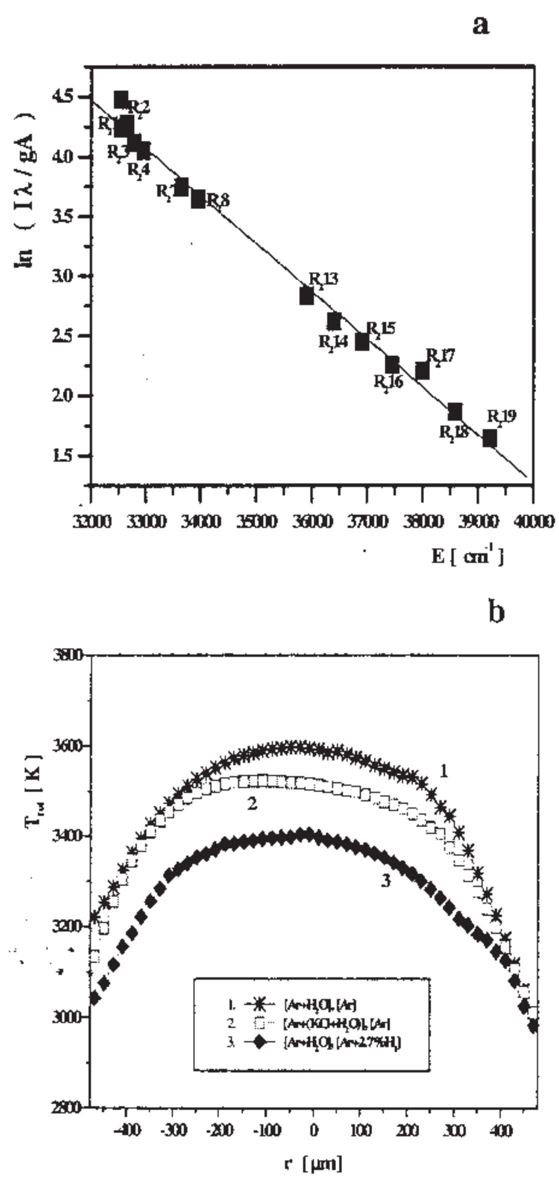

Figure 10. (a) Typical Boltzmann plot at r = 0, i.e. discharge center and H = 2000 μm; (b) Radial distributions of T_{rot} at the axial position of 2000 μm from the torch orifice determined from R - branch of OH band

Typical Boltzmann plot of the P branch of first negative system of nitrogen molecul ion N_2^+ is presented in Figure 9a. Radial distributions of rotational temperature, T_{rot}, determined from N_2^+ band, in the case when wet argon or wet argon with 2 mg/ml of KCl is used as nebulizer gas and argon support gas are given together in Fig. 9b. As you can see from the presented radial distributions maximum T_{rot} in case wet Ar is 4000 K and in case of potassium addition is slightly lower.

Typical Boltzmann plot of the R branch of OH radical is presented in Figure 10 a. Radial distributions of rotational temperature, T_{rot}, determined from OH band, in the case when wet argon or wet argon with 2 mg/ml of KCl is used as nebulizer gas and argon support gas are given together in Fig. 10 b. In this case obtained radial distributions shows that maximum T_{rot} is with wet argon 3600 K.

4. CONCLUSIONS

Reported results on n_e, T_{exc}, T_{rot}, spatial distributios in the presense of water, molecular hydrogen and element of a low ionization potential, indicate that number of processes are involved and that their descriptions and mutual interaction is very complex.

The main value of this work are high quality experimetal data which may be used for reliabile testing of differnts models. Since these models are not available (to our knoweledge) we would like to invite evriybody willing to start modeling of such kind of discharge and we will be ready to perform all additional experiments to help testing of theoretical studies

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M31-2

IV International Conference

Plasma Physics and Plasma Technology

Final Programme

Minsk, Belarus,
September 15-19, 2003

Institute of Molecular and Atomic Physics
National Academy of Sciences of Belarus

4.49 STRUCTURAL AND OPTICAL CHARACTERISTICS OF ZINC OXIDE THIN FILMS FORMED BY REACTIVE MAGNETRON SPUTTERING, Goncharova O., Kalinov V., Zaretskaya E., Gremenok V., Zalesski V., Leonova T.

4.50 LOW-TEMPERATURE PLASMA AND NEW MATERIALS IN FORM OF COMPOSITE POWDERS AND COATINGS, Rudenskaia N.A.

4.51 SURFACE MORPHOLOGY OF THE MATERIALS TREATED BY NITROGEN COMPRESSION PLASMA FLOWS, Anischik V.M., Uglov V.V., Cherenda N.N., Astashynski V.M., Ananin S.I., Kostyukevich E.A., Kuzmitski A.M., Danilyuk A.L., Kvasov N.T.

4.52 INVESTIGATION OF PLASMA PARAMETERS DURING THE ACTION OF COMPRESSION PLASMA FLOWS ON SURFACES, Astashynski V.M., Ananin S.I., Askerko V.V., Avramenko V.B., Bakanovich G.I., Kostyukevich E.A., Kuzmitski A.M.

4.53 NUMERICAL SIMULATION OF COMPRESSION PLASMA FLOWS ACTION ON SOLID TARGETS, Ananin S.I., Astashynski V.M., Emel'yanenko A.S., Kostyukevich E.A., Kuzmitski A.M., Zhvavy S.P.

4.54 MODIFICATION OF HARD METALS BY COMPRESSION PLASMA FLOWS, Uglov V.V., Astashynski V.M., Anishchik V.M. , Kovyazo A.V., Gimro I.G.

4.55 IRON SURFACE CELLULAR STRUCTURE FORMED BY ACTION OF COMPRESSION PLASMA FLOWS, Uglov V.V., Anishchik V.M., Astashynski V.V., Sveshnikov Yu.V., Rumianceva I.N.

4.56 THE PLASMA TREATING OF METAL AND TRANSPARENT DIELECTRICS AS A METHOD OF STRUCTURE CHANGES OPERATING, Chumakov A.N., Ivanov A.Yu., Liopo V.A., Vasilyev S.V.

Thursday – September 18, Afternoon

Hall I
14:00 – 17:45

Plenary Sessions

1. **Malakhov Yu.**

   ISTC ON THE ROAD TO PARTNERSHIP

2. **Konjevic N., Ivkovic M., Jovicevic S.**

   APPLICATION OF HYDROGENIC AND NON-HYDROGENIC SPECTRAL LINE SHAPES FOR LOW ELECTRON DENSITY PLASMA DIAGNOSTICS

3. **Sakka T.**

   SPECTROSCOPIC CHARACTERIZATION OF THE LASER ABLATION PLUME PRODUCED AT SOLID-LIQUID INTERFACES

4. **Petrov O.F., Fortov V.E., Morfill G. E., Semenov Yu.P.**

   TRANSPORT PHENOMENA IN DUSTY PLASMAS UNDER GRAVITY AND MICROGRAVITY CONDITIONS

Hall I
17:45 – 18:15

Closing Ceremony

3.01

APPLICATION OF HYDROGENIC AND NON-HYDROGENIC SPECTRAL LINE SHAPES FOR LOW ELECTRON DENSITY PLASMA DIAGNOSTICS

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Plasma broadened and shifted spectral line profiles are used for a number of years as a basis of an important non-interfering plasma diagnostic method. This technique became, in some cases, the most sensitive and often the only possible plasma diagnostic tool. In the early sixties a number of attempts have been made to improve and to check experimentally existing theories of spectral line broadening by plasmas. Most of these early works were concerned with the Stark broadening of hydrogen lines. For plasma diagnostic purposes considerable interest attracted neutral helium visible spectral lines with forbidden components. Their overall line shapes, which become similar to hydrogen lines at higher electron densities, offer numerous possibilities for electron density determination.

Unfortunately, it is not always convenient to seed plasma with hydrogen or helium and sometimes this is not possible. Furthermore, due to the large Stark effect, hydrogen lines are sometimes inconvenient for plasma diagnostic purposes, since they become so broad at high electron densities that, due to the interference with other neighboring lines, it is difficult to determine their shape correctly. Thus, from the early starts of this field of research, there was an interest for the plasma broadening of isolated non-hydrogenic lines of neutral atoms and positive ions. Due to the quadratic Stark effect, these lines can be used for plasma diagnostic purposes at high electron densities and, in particular, at high electron temperatures when hydrogen is fully ionized.

Since the interest of this paper is focused to plasma diagnostics of relatively low electron density plasmas (widely used nowadays for various applications) we shall confine our further discussion to the use of hydrogen lines, helium lines with forbidden components and non-hydrogenic neutral and singly ionized atomic lines.

Hydrogen lines. Various methods for N_e determinations are well described in a number of textbooks and papers /1-3/. The determination of N_e from the profile of hydrogen Balmer lines and in particular from the H_β (486.13 nm) line is a well-established and widely used plasma diagnostic technique [/1-3/ and references therein]. To achieve the present state of accuracy, considerable experimental and theoretical efforts were involved /1,4/ and as a result, it was established that electron density in the range $10^{22} - 10^{23}$ m^{-3} may be determined from the experimental H_β line widths in conjunction with Vidal, Cooper and Smith (VCS) tables /5/ with an accuracy of 4–7 % /6,7/. The overall agreement of the experimental H_β profile with VCS /5/ is good except for the central part where the theoretical profile always has a larger dip, whose magnitude depends upon both, the electron number density and the mass of the perturbing ions present in the plasma. This discrepancy is related to the effect of ion-dynamics on the line shape /8/. Namely, the authors of VCS /5/ used a quasistatic ion approximation to evaluate the ionic contribution to the line width. Ion dynamics, however, play an important role in the central part of the line profile. The details of various theoretical approaches and, in particular, the influence of ion dynamics on the hydrogen line shape calculations can be found in /4/ and references therein. In order to overcome the problem of the central dip in the H_β line profile, several programs among those developed for using with VCS data tables /5/ for N_e determination /9-13/, neglect this part of the profile /12,13/.

Two recent theoretical calculations, one based on Model Microfield Method (MMM) by Stehle /14/ and another one using computer simulation (CS) by Gigosos /15/, have included ion dynamics in H_β line shape evaluations. This enabled the correct use of the whole H_β line profile, which is of importance for correct and reliable plasma diagnostics. Since fine structure splitting of hydrogen spectral lines is not taken into account none of above mentioned theoretical calculations may be applied with confidence for $N_e < 10^{14}$ cm^{-3}.

For comparing theories with experimental line shape recording and for N_e determinatio, the numerical procedure is developed /16/ and various theories tested.

Recently an attempt is made to increase sensitivity of N_e determination by using half-widths of the higher members of hydrogen Balmer serie. Results of this study will be discussed also in a contributed paper at this conference /17/.

Helium lines with forbidden components. Forbidden transitions are associated with a electric field-induced mixing of upper states in the 2-n optical transitions in He I, a mixing which leads to the transitions normally disallowed by the selection rules for electric dipole transitions. This mixing of states is induced either by the electric field of charged particles in plasmas. Results of several systematic studies will be discussed see e.g. /18/.

Non-hydrogenic line profiles. Short overview of the available theoretical results will be followed by the description of other broadening mechanisms, which may interfere with Stark width and shift determination. Typical experimental procedures and experimental techniques for the line shape and shift measurement will be described. Neutral atom lines asymmetry and new

techniques for ion-broadening parameter measurements will be discussed. The influence of ion-dynamics to the width and shift of neutral helium lines in low electron density plasmas will be examined and the results applied. Other advancements in experimental techniques and procedures are reviewed also. The experimental difficulties and necessary precautions required whenever Stark broadening parameters have to be determined or used for plasma diagnostic purposes will be summarized.

An important part of this paper is devoted to the results of the comparison /19/ experiment versus theory used for the calculation of Stark broadening parameters. This will include theoretical results of both simplified and sophisticated semi classical and recent fully quantum mechanical calculations.

Recent compilation and critical evaluation of experimental Stark broadening data for isolated spectral lines of neutral and ionized atoms published since for the 11-year period 1989 through the end of 2000 /20/ is discussed also. The growth of experimental data has been especially pronounced for multiply-charged ions due to the development and applications of new plasma sources (see also /19/).

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TIME-RESOLVED CHARACTERIZATION OF THE SINGLE- AND DOUBLE-PULSE LASER- PRODUCED PLASMAS

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Pulsed laser ablation plasma is a subject of extensive studies for thin film deposition, fabrication of nanostructures, vaporization of sample material for spectrochemical analysis, etc. /1,2/. For selection of optimal plasma conditions in these applications the detailed understanding the physical and chemical processes in the ablation plasma and reliable methods for controlling of the relative amounts of plume species are needed. Different laser-induced effects through mechanisms of laser-surface and laser-plasma interactions may be useful for the control of plume characteristics. In this context, the double-pulse laser ablation technique leading to better coupling of laser pulse energy to the target and ablated matter is of great interest /3,4/. This paper presents diagnostic data and a comparative analysis of plasma parameters in the single- and double-pulse laser ablation processes. Emission dynamics of ions and molecules produced by double-pulse laser ablation have been examined. The possible mechanisms of changes of near-surface plasma parameters by the second laser pulse have been discussed.

1. EXPERIMENTAL

The experiments were carried out using a set-up described in details previously /5/. Briefly, the second (SH) harmonic (532 nm, 1-4 J/cm^2) of the Nd-YAG laser in combination with the fundamental harmonic of another Nd-YAG laser or with excimer XeCl (308 nm, 10 ns, 1-2 J/cm^2) laser radiation at different temporal delays between pulses were employed for ablation. The laser beams were focused on the surface of the metal (aluminum, silver, copper) or graphite samples under vacuum, or gas (air, helium) environments.

Optical observation of the plasma emission was performed by imaging the section of the plasma plume onto the entrance slit of monochromator equipped by the fast photomultiplier. The emission spectra of plasma were recorded in the UV and visible region. The detection of the photomultiplier signals was accomplished by a transient digitizer, connected to a personal computer for data processing and analysis.

The quantitative information on plasma parameters, like electron temperature, electron density, spatial and temporal evolution of atomic species was obtained by combination of the time-resolved optical emission spectroscopy

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APPLICATIONS OF SPECTRAL LINES FOR LOW ELECTRON DENSITY PLASMA DIAGNOSTICS

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Abstract. This work comprises an analysis of optical emission spectroscopy (OES) techniques and results of their application for diagnostics of middle and low electron densities (N_e) in low temperature plasmas. The discussion will be limited primarily to the applications of the methods based on the use of: Stark – widths and shifts of non-hydrogenic neutral and singly ionized atom lines, line shape of neutral helium lines with forbidden components and molecular nitrogen band heads intensities. In this study all these techniques are critically evaluated, tested and applied for diagnostics of microwave induced plasma (MIP), low pressure pulsed arcs or capillary discharge.

1. INTRODUCTION

Low and medium electron density plasmas are extensively used in analytical atomic spectroscopy as a light sources for optical emission spectroscopy (OES), plasma processing and in various technologies, such as laser ablation, thin film deposition, creation of different nanostructures and nanocomposite etc. Therefore, the interest for plasma diagnostics is growing, and the need for improvement of old and development of new techniques is a constant task. Due to their non-perturbative nature, high spatial resolution and variety of different methods, the OES techniques are of particular interest.

In this study, the discussion will be limited primarily to the diagnostics of electron density, N_e, in low temperature plasmas using of non-hydrogenic spectral lines. For other plasma parameters measurements and application of hydrogenic spectral lines for N_e diagnostics, more details can be found in several recent review articles and textbooks [1-5] and references cited therein. Within this work techniques based on Stark – widths and shifts of non-hydrogenic ion and atom spectral lines, thr overall line shape of helium atom lines with forbidden component and molecular nitrogen band heads intensities are studied. All these techniques are applied and tested in different plasma sources and theirs advantages and drawback discussed.

2. EXPERIMENT

In experimental part of this study two different setups were used. One for the investigations of low pressure pulsed capillary discharge and another one for an atmospheric pressure microwave induced plasma studies. The central part around the axis of the pulsed plasma source is imaged 1 : 1 onto the entrance slit of the 1 m monochromator (inverse linear dispersion 0.833 nm/mm) by means of a 1 m focal length focusing mirror. A 30 mm diaphragm placed in front of the focusing mirror ensures that light comes from the narrow cone about the discharge axis. The spectral line profiles are recorded step-by-step with the instrumental half width of 0.017 nm. Signals from the photomultiplier - PMT are led to a digital storage oscilloscope triggered by the signal from the Rogowsky coil. The main current pulse through the discharge tube induces the trigger pulse. In order to obtain better signal-to-noise ratio an averaging of eight signals at each wavelength step is performed. For more details see references [6, 7].

In cases when radiation from the microwave induced plasma sources – MIP was measured, the 1:1 image is projected on the 20 μm wide slit by use of a 0.5 m focal length focusing mirror. In that case, signal from the PMT was amplified by the picoammpermeter. More details about sample introduction, gas flow control when using different versions MIP sources one can find in [5, 8].

3. RESULTS

In the following section in front of the experimental and/or mathematical testing of the methods, short review of theirs fundamental characteristics will be presented.

3. 1. Neutral and Singly Ionized Non-hydrogenic Atom Lines

The use of Stark widths and shift of ionized non-hydrogenic atom lines for diagnostics of the electron densities lower than 10^{22} m^{-3} is very rare. At these densities Stark widths are small and comparable with widths due to the other broadening mechanisms, so that high-resolution spectroscopic instrumentation has to be used and deconvolution procedures must be applied.

3.1.1. The Width and Shift of the Neutral Atom Lines

The shape of the neutral atom line in quasistatic approximation for ions is described by the following expression [9]:

$$j_{A,R}(x) = \frac{1}{\pi} \cdot \int_0^{\infty} \frac{H(\beta)\, d\beta}{1 + \left(x - A^{4/3} \cdot \beta^2\right)^2} \qquad (1)$$

where H(β) is ion microfield distribution, and x is described by $x = (\lambda - \lambda_0 - d_e)/w_e$, λ_0 is the central wavelength of the unperturbed line, d_e is the electron shift and w_e is the electron impact half-halfwidth. Examples of neutral atom plasma broadened line shape for Debye shielding parameter R = 0.8 and different values of ion broadening parameter A are presented in Figure 1.

From a large number of generated profiles Griem [4] found that total Stark (full widths at half maximum FWHM) - w_t of line profiles could be expressed within the quasistatic ion approximation as a function of w_e, A and R

$$w_t(T_e) \cong 2w_e(T_e)[1 + 1.75\text{x}10^{-4}N_e^{1/4}A(T_e)(1 - 0.068N_e^{1/6}T_e^{-1/2})]10^{-16}N_e \qquad (2)$$

$$d_t(T_e) \cong [d_e(T_e) \pm 2.0\text{x}10^{-4}N_e^{1/4}A(T_e)\, w_e(T_e)(1 - 0.068N_e^{1/6}T_e^{-1/2})]10^{-16}N_e \qquad (3)$$

$$d_{t1/2}(N_e,T_e) \approx [d_e(T_e) \pm 3.2\text{x}10^{-4}Ne^{1/4}A(T_e)w_e(T_e)(1 - 0.068N_e^{1/6}T_e^{-1/2})]10^{-16}N_e \qquad (4)$$

where w_t, d_t and $d_{t1/2}$ are measured Stark widths and/or shift of the peak line intensity or shift of the halfwidth, respectively, while w_e, d_e, and A are theoretical electron impact half-halfwidth, d_e shift and A ion broadening parameter calculated for $N_e = 10^{16}$ cm^{-3} and published in Appendix IV of [4].

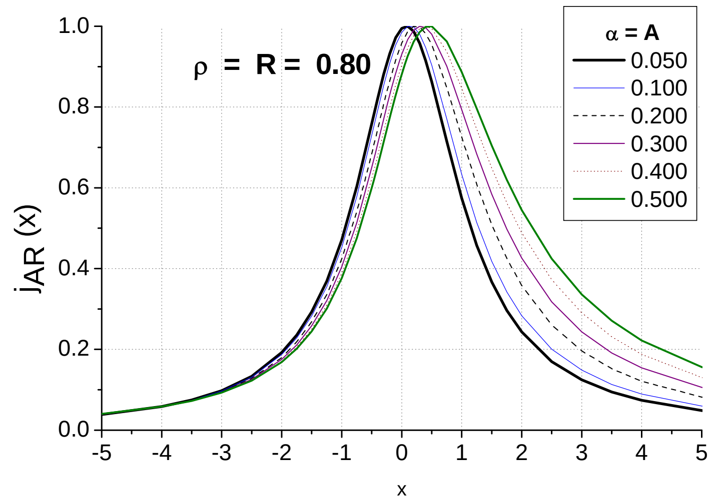

Fig 1. The $j_{A,R}(x)$ profiles of neutral atom lines for R = 0.8 and different values of A

It should be noticed that plasma broadened neutral atom lines are asymmetric and that the deconvolution procedure, see e.g. [10,11], differs from symmetric profiles of, for example, ionic lines, see e.g. [12]. Influence of ion dynamics especially in case of light elements such as helium [13,14] is also important and must be taken in account. For a number of lines correction factors w_{exp}/w_t determined by Konjevic [15] from the comparison of theory and large number of high accuracy experimental data. This enables more precise electron density determination.

This technique was tested in the capillary discharge with gas mixture of 2.4% Ne, 5.6% He and 92 % H_2 at pressure p = 4 mbar. The maximum discharge current of I = 400 A with t = 2.7 □s was obtained by discharging C = 0.36 □F, charged up to U = 7 kV. By use of excitation temperature T_{exc} = 33 000 K determined from Boltzmann plot of O II lines, correction factors from [15] and tabulated values of w_e and A [4] the electron density N_e= (4.8 ± 0.2) x 10^{22} m^{-3} from the He I : 388.8, 471.3 and 501.6 nm spectral lines was determined. For the determined electron density and w_e value in Appendix IV of [4] for Ne I spectral line at 594.483 nm very good agreement between experimental and generated Voigt profile was obtained. The observed Ne I lines were symmterical, within the uncertainty of experiment indicating that small ion broadening contribution is small, see Figure 2.

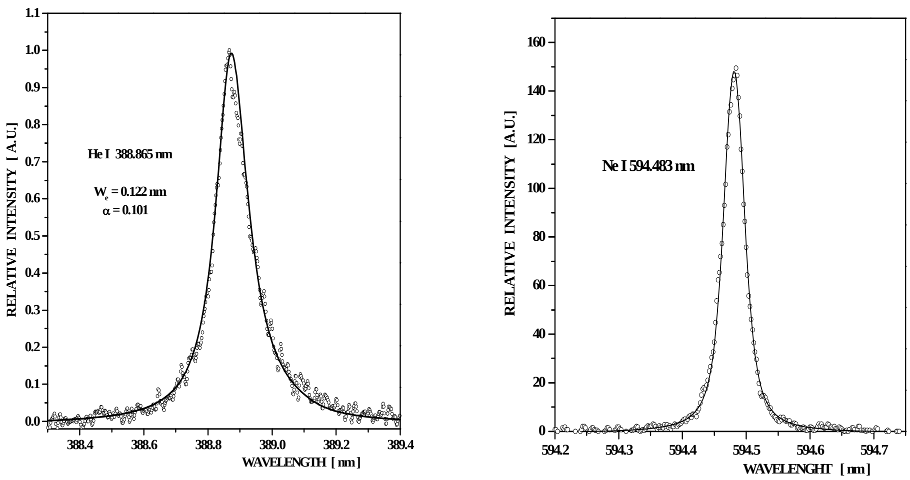

Fig 2. a) The recorded He I 388.865 nm line (○) fitted with j_{AR} (x) theoretical profile with data taken from [4] for N_e = 5.2 x 10^{22} m^{-3} and T_e = 33000 K and b) The recorded Ne I 594.483 nm line (○) fitted with Voigt profile for N_e = 4.8 x 10^{22} m^{-3} and T_e = 33000 K.

It should be notices that from fitted j_{AR} (x) profile of the He I 388.8 nm line We = 0.122 nm i.e. N_e = 5.2 x 10^{22} m^{-3} is obtained, but after applying w_{exp}/w_t correction factor determined in [15] the value of 4.8 x 10^{22} m^{-3} is determined.

3.1.2. The Comparison of the Theoretical and Experimental Profiles

The another and more accurate way for electron density determination is based on comparison of whole experimental and theoretical line profiles, see example in Fig.2 [16-18]. In order to test the possibility of determining plasma and line parameters by using deconvolution techniques and especially the six fit parameter deconvolution - SFPD procedure [18] from one line profile only (without independent plasma parameters and shift measurements) the theoretical line profiles are generated from Eq.(1). We analyzed theoretical profiles $j_{A,R}(x)$ with the following sets of parameters: 1) various R values ($0 \leq R \leq 0.8$) and largest value of A = 0.075 reported in [19]; 2) different pairs of A and R values with fixed electron impact $w_{e,}$ and ion contribution w_i and 3) fixed total Stark widths w_t and R values for various sets of w_e and A.

The Case 1. is illustrated by Fig. 3. The FWHM of these lines for the whole range of R changes from 2.133 to 2.188, i.e. difference is only 0.055 (in x units) while shapes are very similar. This means that for typical w_e values around 0.1 nm at 10^{17} cm^{-3} [19] the difference in half width corresponds to only 0.0055 nm for the whole range of R values. Such a small difference between profiles in a large range of R values raises a question: Is any deconvolution capable of detecting so small differences of line shapes in particular if one is using pulsed plasma source and shot–to-shot technique for line profile recording or study the astrophysical plasmas.

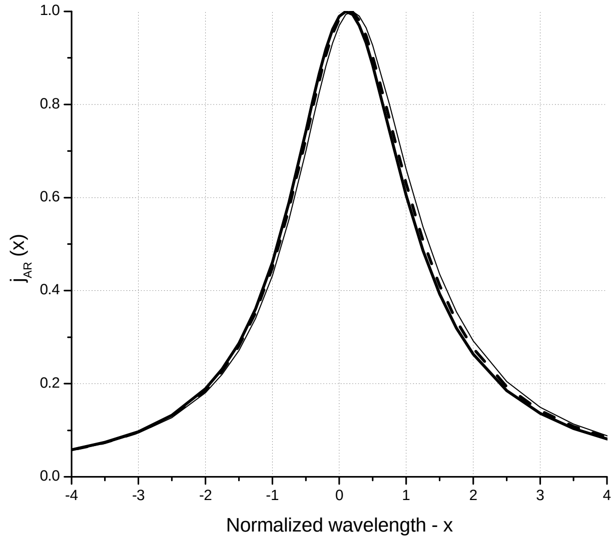

FIGURE 3. The $j_{A,R}(x)$ profiles of neutral atom lines for $w_e = 2$, $d_e = 0$, A = 0.075 and different values of: R = 0 (thick line), 0.4 (dashed line) and 0.8 (thin line).

In the Case 2., from Eq. (2), after several iterations of this approximate formula many (A,R) pairs with the same electron impact, w_e, and ion contribution, w_i, i.e. with the same total Stark width w_t are determined, see several examples in Table 1.

Table 1. Different sets of parameters for the same w_t and total ion shift d_{it}. A_1- calculated from Eq.(2), A_2- determined by an iteration process.

w_e	w_t	d_i	R	A_1	A_2
2	2.41	0.47	0.55	0.2	0.2
2	2.41	0.47	0	0.118	0.142
2	2.41	0.47	0.2	0.138	0.162
2	2.41	0.47	0.8	0.294	0.24

The shapes of the lines with parameters given in Table 1 are practically indistinguishable in a typical line profiles presentation. Consequently, the line shape only cannot be used for plasma diagnostics and line parameters determination.

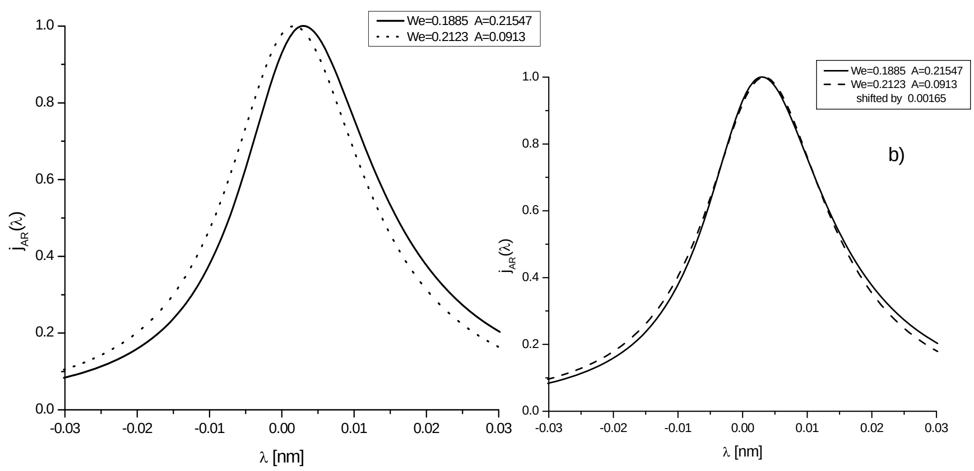

Fig 4. The $j_{A,R}(x)$ profiles for R = 0.48 and different values of w_e and A; w_e = 0.188, A = 0.215 (solid line); w_e = 0.212, A = 0.091 (dotted line). a) shifted profiles and b) profiles with the shift normalized to the same value.

In the Case 3, by using Eq.(2), whole set of (w_e, A) pairs for the same value of w_t and R were calculated. In this case profiles are not identical, but they differ slightly at the line wings, see Fig. 4b. These differences are so small that deconvolution of profiles recorded from pulsed sources using shot-to-shot technique in the presence of impurity lines can't distinguish one from another. Figure 4a illustrates the importance of precise shift measurements for determination of N_e in these cases.

The analysis of line profiles is even more complex when all three parameters w_e, A and R are varied. With different combinations of these parameters profiles with exactly the same w_t with very small differences in shape can be obtained.

3.2. Helium lines with Forbidden Component

In the case of helium plasmas, electron density can be determined by using the shape of some visible He I lines with forbidden components. These strong lines, belonging to the $2^3P – n\ ^3D$ series (n = 4 for 447.1 nm and n = 5 for 402.6 nm) and to the $2\ ^1P – n\ ^1D$ series (n = 4 for 492.2 nm), have in plasma forbidden components 2^3P- n ^3F or 2 ^1P - n ^1F, respectively. The complex structures of these lines, see Fig.5, are extensively studied both theoretically, by applications of unified, MMM or close coupling (CC) theories, and experimentally. The inclusion of ion dynamic effects in theoretical descriptions of helium lines with forbidden components greatly improves agreement with experimental results.

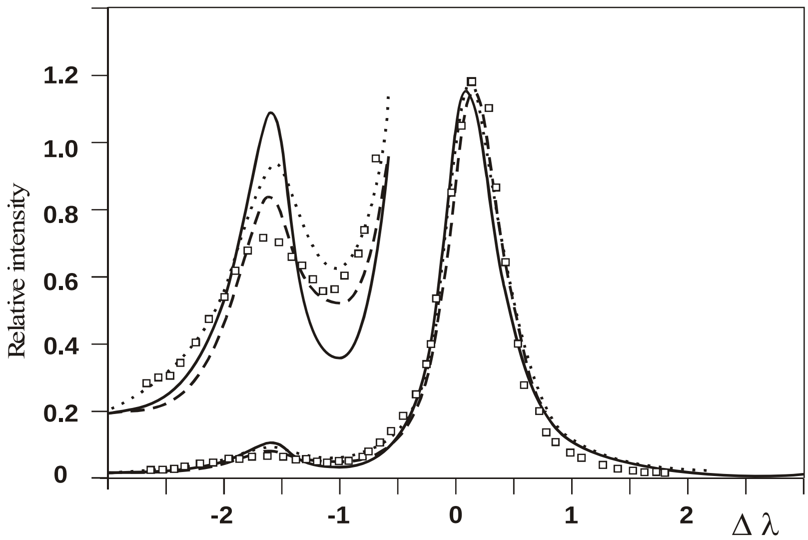

Fig. 5. Comparision of measured He I 447.1 nm line shape (squares) with theory: MMM (full), CC (dashed),and BCS (doted line).Plasma parameters: $N_e = 1 \times 10^{15}$ cm^{-3}, T_e=18 000 K, T_g = 13 000 K. Doppler and instrumental broadening included and all profiles are area normalized.

However, as illustrated in Fig. 5, the discrepancy of predicted forbidden line intensity with the experiment [20] still remains for all three theoretical approaches.

This is a main reason why experimentally determined formulas relating N_e with the parameters of helium lines with forbidden component such as F/A - forbidden (F) to allowed (A) line maximum intensity, D/A - deep (D) i.e. minimum intensity between forbidden and allowed line and A line intensity) and *s* - wavelength separation between F and A. determined by Czernichowski and Chapelle [21] are mainly used. Due to the fact that parameter *s* is not sensitive to distortion of the strong allowed line caused by the possible presence of a self-absorption effect, the following relation was used in this work

$$\log N_e\,[m^{-3}] = 23.056 + 1.586 \log (s[nm] - 0.156) + 0.225\,[\log (s - 0.156)]^2 \qquad (5)$$

where 0.156 nm in Eq.(6) is the separation between unperturbed F and A line.

The application of He I 447.2 nm line for determination of the medium electron densities was applied in the capillary discharge at p=4 mbar of gas mixture 1.5% CO_2, 1.5% N_2 and He, see Figure 6. The capacitor of 0.36 □F charged up to the 6 kV was used to obtain peak current with duration of 3.6 □s.

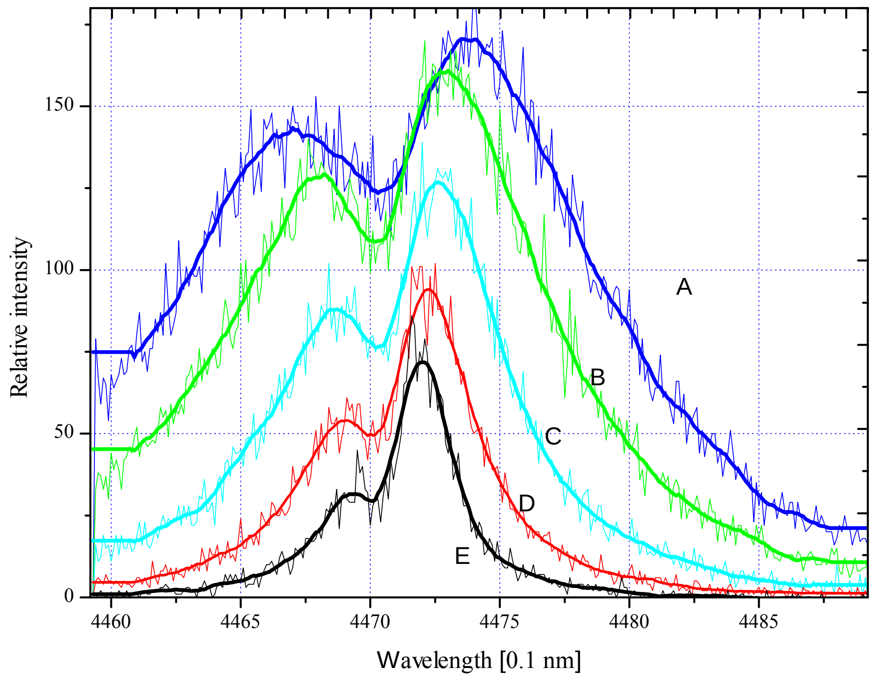

FIGURE 6. The shapes of the 447 nm line during plasma evaluation (A - 3.5; B - 4.5; C - 5.5; D - 6.5 and E - 7.5 □s after current maximum),

which corresponds to the Ne = 3.4; 1.9; 1.2; 0.78 and 0.35 $*10^{16}$ cm^{-3} respectively. The same procedure can be used for lower N_e determination, but with a use of a different amplification when recording forbidden or allowed component, as shown in Figure 7. It should be pointed out that great care must be taken when using He I lines with forbidden components for the determination of N_e lower than few times 10^{14} [cm^{-3}]. At these densities, the low intensity of the forbidden component (less than few percents of the allowed one), may be masked by noise or in the presence of traces of nitrogen, molecular lines from 6-8 and 8-10 bands of the first negative system of N_2^+.

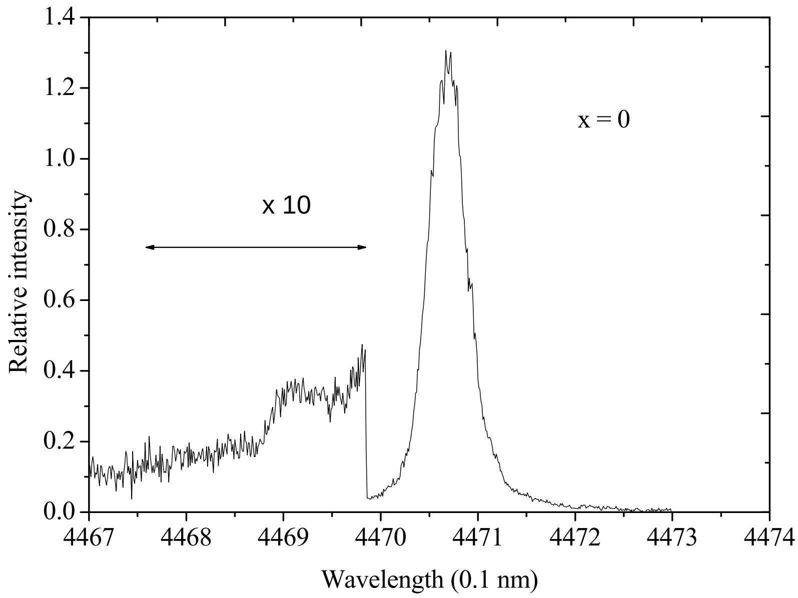

Fig. 7. Illustration of line shape recordings with different amplification of the photomultiplier signal. Line emitted from the center of the Mini MIP at height of 1mm from the torch orifice. The flow rate of He through the outer was 0.6 l/min, and He+ 3% H_2 through the inner capillary was 0.2 l/min.

3.3. Intensity of the N_2 and N_2^+ Molecular Band Heads

According to [22-24], the electron density in nitrogen and nitrogen/He plasmas can be determined from the intensity of N_2 second positive system (SPS) band head (0-0) at 337.1 nm ($C\ ^3\Pi_u \rightarrow B\ ^3\Pi_g$) and N_2^+ first negative system (FNS) band head of (0-0) at 391.4 nm ($B^2\Sigma_u^+ \rightarrow X^2\Sigma_g^+$).

Namely, by using the simplified kinetic model of the N_2 ($C^3\Pi_u$) state, see e.g. [23] and assuming that the steady-state population of the upper energy state is equal zero, a linear relation between the 337.1 nm band intensity and the electron density at constant pressure and constant electric field may be obtained. This relation is confirmed with 5% accuracy in a volumetric near field microwave plasma [24].

A similar discussion can be applied to the band head of First Negative System of nitrogen ion ($B^2\Sigma_u^+ \rightarrow X^2\Sigma_g^+$) [23]. Due to an additional excitation process for the upper level population, the intensity of the 391.4 nm line has quadratic dependence upon electron density, i.e. $I_{(391.4\ nm)} \sim N_u \sim A\ N_e^2 + B\ N_e$, where N_u is the population of the $B^2\Sigma_u^+$ state, while A and B are constants, which must be independently determined.

According to the authors [22], this method can be applied even in plasmas with non-Maxwellian electron energy distribution.

To apply the same method for N_e determination in other gas mixtures, N_2^+ ion fraction has to be calculated. The situation is more complex if Ar or H_2 are present in the gas mixture. The reactions $Ar^* + N_2 \rightarrow Ar + N_2^+$, $N_2^+ + H_2 \rightarrow N_2H^+ + H$ and $Ar^* + H_2 \rightarrow Ar\ H^* + H$ and many others, have to be taken into account.

The band intensity method is tested in MIP at atmospheric pressure with power input of 100 W and at constant He flow rate of 0.7 l/min. The radial distributions of the band head intensities and hydrogen Balmer beta line shapes – H□ are obtained by Abel inversion procedure. From the determined H□ line shapes electron densities are calculated using approximate experimental formula, see Eq.2 in [5]. Finally, dependence of the molecular nitrogen band head intensities versus log N_e for different values of radius are presented in Figure 8.

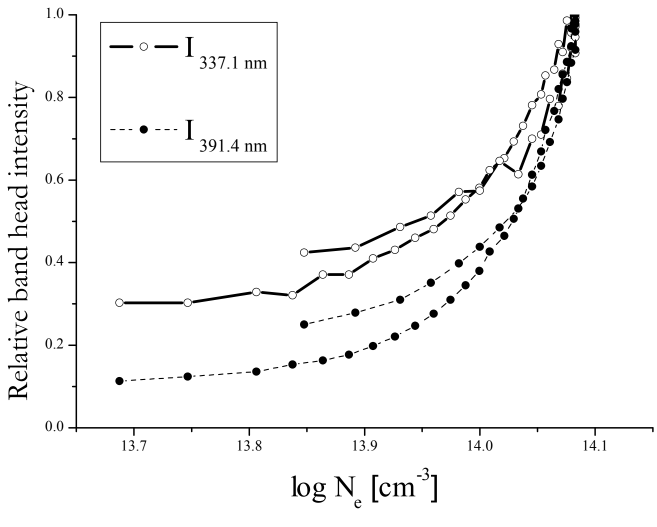

Fig. 8. Dependence of the molecular nitrogen band head intensities versus log N_e for different values of radius in MIP at atmospheric pressure Power input 100 W and flow rate of He 0.7 l/min.

It is evident that the application of this method for N_e determination requires further elaboration and experimental verifications in different plasma sources and gas mixtures. It should be noticed that the calibration of log N_2^+ band intensity vs. log N_e determined using another independent diagnostic technique enables slope parameter determination. The extrapolation of intensity vs. N_e plot may be used for lower N_e plasma diagnostics.

4. CONCLUSIONS

At the end one can conclude that fitting of the neutral atom line profiles is usefull for the medium electron density diagnostics, but a great precautions must be undertaken. This is especially important when more than one parameter fit of only one line without shift measurements is used for several plasma parameters determination.

The helium lines with forbidden components can be used in a very broad range of electron densities and even at lower than 10^{15} cm^{-3}. For lower densities the more complicated procedure must be used and furher theoretical studies will be welcomed.

It should be stressed out that the molecular nitrogen band heads intensities offer a greatest possibility for diagnostics of very low densities, but a both theoretical and experimental studies in different plasma conditions are needed.

ACKNOWLEDGMENTS

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M31-4

Invited Lectures

Jacques Baudon (France) *Elastic and inelastic scattering of fast and slow metastable atoms by micro- and nano-structures*

Joachim Burgdorfer (Austria) *Interaction of ultrashort laser pulses with clusters: short-time dynamics of a nanoplasma*

Stefano Ciroi (Italy) *Plasma diagnostics in the Active Galactic Nuclei environment*

Emanuela Danezis (Greece) *The peculiar absor-ption/emission lines phenomena from stars to quasars*

Nikolay A. Dyatko (Russia) *Jumps and bi-stability effects in low temperature plasmas*

Albert Ellingboe (Ireland) *Assessing plasma source technology for manufacturing*

Juergen Fassbender (Germany) *Ion beam modifications of magnetic films*

Timo Gans (Germany) *Diagnostics for the Dynamics of Power Dissipation in Technologically used Plasmas*

Bill Graham (UK) *Atmospheric pressure glow discharges*

Russell Gwilliam (UK) *Vacancy engineering for the production of ultra shallow junctions*

John Douglas Hey (South Africa) *Spectroscopic studies of atomic and molecular processes in the edge region of magnetically confined fusion plasmas*

Sergej Kuhlevski (Hungary) *Soft-x-ray Ar+8 lasers by non-ablative slow Z-pinches in 0.5-m capillaries: Experiment and theory*

Klaus-Peter Lieb (Germany) *Gloomy quartz: electroluminescence in ion-irradiated and epitaxially recrystallizing quartz*

Manon Lourenco (UK) *Microstructural influence on electroluminescence of silicon light emitting diodes*

Charlie Mahony (UK) *Medium and small scale plasmas for nanotechnologies at the UU Nanotechnology Research Institute*

Nigel J Mason (UK) *Probing radiation damage at the molecular level*

François Mathis (France) *Unusual applications of ion beam analysis for the study of surface layers on materials relevant to cultural heritage*

Vladimir Mezentsev (UK) *Role of plasma in femtosecond laser pulse propagation*

Tomohiro Morisaki (Japan) *Effect of Magnetic Field Topology on Edge Plasma Behavior in LHD Heliotron*

Osamu Motojima (Japan) *Frontier of Fusion Research: Path to the Steady State Fusion Reactor by Large Helical Device*

Valentin Ostrovsky (Russia) *Threshold laws for multiple ionization of atoms*

Svetozar Popović (USA) *Aerodynamic effects in weakly ionized gas: phenomenology and application*

Jan Dusan Skalny (Slovakia) *Spectra of ions produced by corona discharges*

Richard Taieb (France) *IR vs. X-rays strong field atomic physics*

Ronald White (Australia) *Non-equilibrium electron transport in gases*

Progress Reports

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Daniel Caceres (Spain) *Aminoacid formation by electron irradiation*

Cormac Corr (France) *Transition from unstable electrostatic confinement to stable magnetic confinement in a helicon reactor operating with Ar/SF_6 gas mixtures*

Marco Gigosos (Spain) *Study on the asymmetry of the Balmer lines*

Milivoje Ivković (Serbia) *Optical emission spectro-scopic techniques for low electron density diagnostics*

Predrag Jovanović (Serbia) *Microlensing signatures in spectra of quasars: X-ray radiation*

Predrag Krstić (USA) *Chemical sputtering at the fusion-plasma facing carbon surfaces*

Kinga Kutasi (Portugal) *Modelling of a post-discharge reactor used for plasma sterilization*

Violeta Lazić (Italy) *Laser-induced plasma spectroscopy: principles, methods and applications*

Joana Marler (USA) *High resolution cross section measurements using a trap based positron(electron) beam*

Jorge Mahecha (Colombia) *Quantum and classical description of H atom under magnetic field and quadrupole trap potential*

Čedomir Maluckov (Serbia) *Investigation of the statistical nature and structure of the electrical breakdown time delay in gas diodes filled with neon*

Stefan Matejcik (Slovakia) *Electron attachment and electron impact ionization of simple aminoacids*

Velimir Milinović (Germany) *Ion beam mixing at crystalline and amorphous Si/Fe interfaces*

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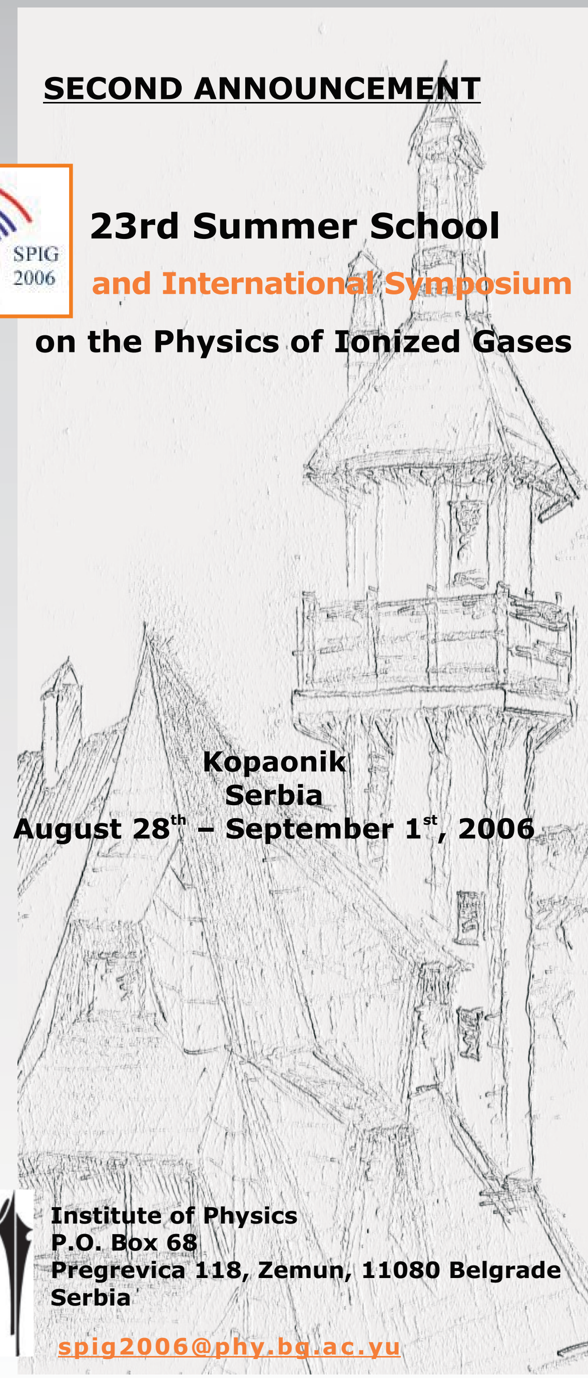

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Optical Emission Spectroscopic Techniques for Low Electron Density Diagnostics

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Location: National Park Kopaonik (Serbia)

Abstract

This paper comprises an analysis of optical emission spectroscopy (OES) techniques and results of their application for diagnostics of middle and low electron densities in low temperature plasmas. The following OES diagnostic techniques based on: 1) line merging along spectral line series, 2) use of line shapes and Stark halfwidths of hydrogen Balmer lines, 3) line shape of helium lines with forbidden components and 4) use of molecular nitrogen bandhead intensities are studied, discussed, tested and applied and in some cases ugraded for electron density measurements. The overall comparative analysis is performed also.

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Key Topics

Emission
spectroscopy
Plasma diagnostics
Atomic line shapes
Optical plasma
diagnostics
Density measurement

Optical Emission Spectroscopic Techniques for Low Electron Density Diagnostics

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Abstract. This paper comprises an analysis of optical emission spectroscopy (OES) techniques and results of their application for diagnostics of middle and low electron densities in low temperature plasmas. The following OES diagnostic techniques based on: 1) line merging along spectral line series, 2) use of line shapes and Stark halfwidths of hydrogen Balmer lines, 3) line shape of helium lines with forbidden components and 4) use of molecular nitrogen bandhead intensities are studied, discussed, tested and applied and in some cases ugraded for electron density measurements. The overall comparative analysis is performed also.

Keywords: Optical emission spectroscopy; electron density diagnostics

PACS: 52.25Ya, 32.70.Jz,52.70Kz

INTRODUCTION

Low and medium electron density plasmas are extensively used in analytical atomic spectroscopy as a light sources for optical emission spectroscopy (OES), for plasma processing and in various technologies, such as laser ablation, thin film deposition, creation of different nanostructures and nanocomposite etc. Therefore, the interest for plasma diagnostics is growing, and the need for improvement of old and development of new techniques is a constant task. Due to their non-perturbative nature, high spatial resolution and variety of different methods, the OES techniques are of particular interest.

In this study, the discussion will be limited primarily to the diagnostics of electron density, N_e, in low temperature plasmas by techniques based on: 1) line merging along spectral line series, 2) use of line shapes and Stark halfwidths of hydrogen Balmer lines, 3) line shape of helium lines with forbidden components and 4) use of molecular nitrogen band head intensities. For other plasma parameters measurements, more details can be found in several recent review articles and textbooks [1-4] and references cited therein. Within this work all these techniques are applied and tested in different plasma sources and theirs advantages and drawback discussed.

2. EXPERIMENT

A schematic diagram of the experimental setup is presented in Fig.1. Instead of low-current, 8A, U shaped argon stabilized arc plasma at atmospheric pressure, shown in this Figure and described in details elsewhere [5, 6], a so-called “open capillary” configuration MIP (single 30 mm long Al oxide tube with 6 mm external and 2 mm inner diameter, inserted in the center of cavity) and Mini MIP torch were also used. More details about MIP sources and experimental procedure one can find in [7].

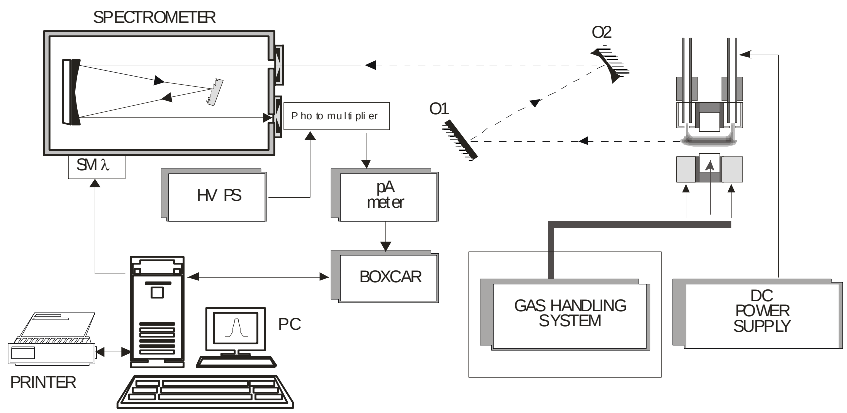

FIGURE 1. Schematic diagram of the experimental setup
SM - step motor; HVPS **-** high voltage power supply, $\mathbf{O}_1$ - plane mirrors; O_2 - mirror focal length 50 cm

3. RESULTS

Within this section short review of OES techniques and results of theirs application for N_e diagnostics of low electron density plasmas were presented.

3.1. Series Limit

The oldest one is the so-called Inglis-Teller method for N_e determination from the line merging along spectral series [8], see also [9]. This formula relates the upper level principal quantum number, n_{max}, of the last detected line along spectral series with N_e:

$$\log (N_e + N_i) = 23.26 - 7.5 \log n_{max} + 4.5 \log z \qquad (1a)$$

where N_i is plasma ion density and z-effective nuclear charge (z = 1 for singly charged ions), when electron velocity is sufficiently small, i.e. when condition [9]

$$T < \frac{4.6 \times 10^5 \quad z}{n_{max}} [K] \qquad (1b)$$

is fulfilled. By assuming $N_e = N_i$, the electron density may be determined by identifying the last spectral line in the series and introducing n_{max} in Eq.(1). For example, for H_ε line of the Balmer series $n_{max} = 7$. In [9] the envelope of merging lines is used to increase the accuracy of Eq. (1) for N_e determination. The Inglis-Teller method offers remarkable possibilities, especially at low N_e, where the accuracy of the method increases (larger number of lines is detected), and the error may be as low as a few percents [9]. The possibilities and difficulties in the determination of N_e are illustrated in Fig.2, see also [10]. Although neutral argon lines interfere with hydrogen lines belonging to the Balmer series, the latter are clearly discernible and the series limit may be easily determined. For n_{max} = 10, see Fig.2, and assuming $N_e = N_i$, the electron density in the range of 1.4 to 2.9 x 10^{21} m^{-3} (11 <n_{max}< 10) is estimated.

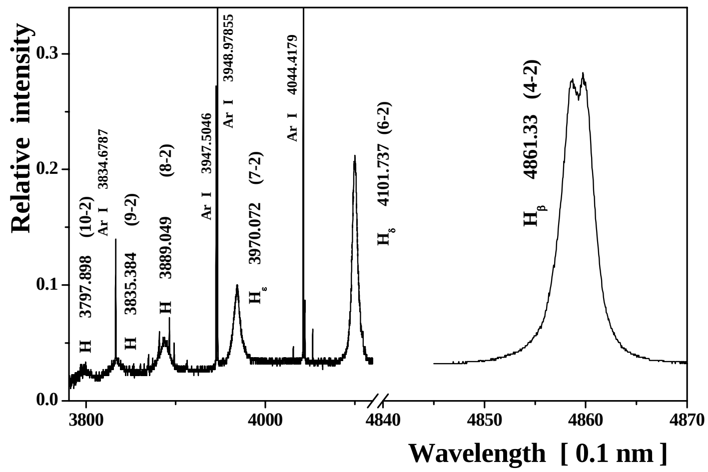

FIGURE 2. Spectra recording of some hydrogen Balmer lines at a axis of the U shaped DC argon arc at atmospheric pressure with current of 8 A

3.2. Hydrogen Balmer Beta Line

Since the beginning of the sixties, the most frequently used techniques for N_e determination is based on the half-width and shape of the hydrogen Balmer beta (H_β = 486.13 nm) spectral line. On the basis of a numerous tests we proposed [5] use of approximate formula between N_e and line Stark width W_S determined by Wiese [11],

$$N_e \ [m^{-3}] = 10^{22} \cdot \left(\frac{W_S}{4.7333} \right)^{1.49} \tag{2a}$$

with W_s previously determined from Keleher approximate deconvolution formula [12]

$$W_S = \left(W_m^{1.4} - W_{DI}^{1.4} \right)^{\frac{1}{1.4}}$$

$$W_{DI} = \left(W_D^2 + W_I^2 \right)^{0.5}$$

$$W_D = 3.58 \cdot 10^{-7} \ \lambda \left(\frac{T_g}{M} \right)^{0.5} \tag{2b}$$

where, W_m is the measured H_β HWHM, while W_I and W_D are the instrumental and Doppler broadening HWHM (all in 0.1 nm units), T_g – gas temperature and M is the ion mass.

After analysis of a numerous programs for N_e determination from the fitting of whole profiles, a new one is made [13]. This program enables use of: area or intensity normalization and excluding a different parts of experimental profiles during comparison with one of three theories. Other manipulation of input data such as smoothing, shift, export etc. and graphic presentation were enabled in Windows version, which main screen was shown in Figure 3a. Program was tested with most accurate experiments with independatly determined N_e in range of two order of magnitude and some of the obtained data are shown in Figure 3 and summarized in Table 1.

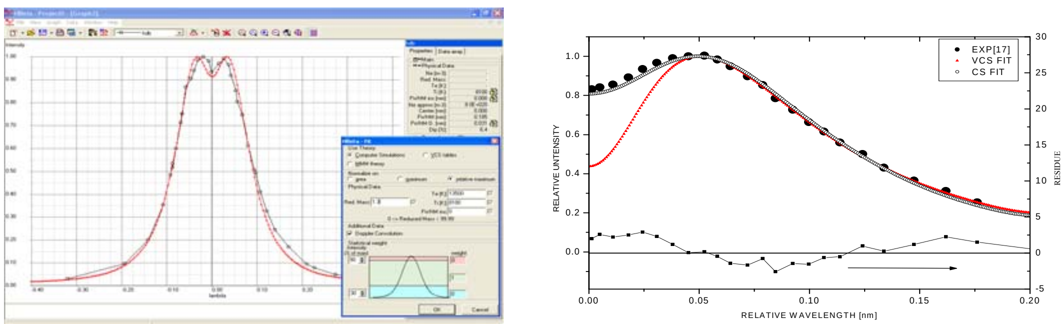

FIGURE 3. a) Illustration of windows main screen of "Hbeta" program
b) Example of comparison of experimental and theoretical data, se Table 1.

TABLE 1. Experimental conditions and results of comparison.

Figure	3a	3b
Reference	[14]	[11]
Reduced mass μ	1.3	0.5
Electron temperature [K]	13500	13400
Ion temperature[K]	8100	13400
Instrumental FWHM[nm]	0 unknown	0.03
Experimental $N_e[m^{-3}]$	8.3 E+20	8.3 E+22
Approximate N_e Eqs.(2) $[m^{-3}]$	8.01 E+20	7.85 E+22
VCS FIT N_e $[m^{-3}]$	8.77 E+20	8.17 E+22
MMM FIT N_e $[m^{-3}]$		7.66 E+22
CS FIT N_e $[m^{-3}]$	7.98 E+20	7.41 E+22

3.3. Higher Members of Hydrogen Balmer Series

The electron density can be detrmined from the line profiles of higher members of spectral series. It is already known that these lines are for the same N_e broader than H_β and influence of the other broadening mechanism smaller. The use of line wings of these lines [15] is troublesome due to the existance of neithborough atom or molecular lines. Therefore, another method for N_e determination that requires, for example, comparisons of theoretical and experimental half width only would be more appropriate. To achieve this goal, Bengston et all. [16] used impact approximation for electrons and quasistatic approximation for ions to calculate hydrogen H_6 – H_{12} Balmer lines Stark widths. With theoretical data of line full halfwidth, summarized in Table 2, N_e from the lines presented in Figure 2, is evaluated using formula (3)[16]:

TABLE 2. Data [16] and results [10] for several Balmer lines measured in U shaped Ar arc (see Fig.1): $\alpha_{1/2}^n$ – normalized line width, W_m – measured FWHM and W_g –contribution of Gausian part.

Transition	$\alpha_{1/2}^n$ [13]	W_m [nm]	W_g [%]	N_e [m^{-3}]
6 – 2	0.150	0.73	5.6	2.71 x 10^{21}
7 – 2	0.184	0.86	4.7	2.56 x 10^{21}
8 – 2	0.283	1.30	3.1	2.49 x 10^{21}
9 – 2	0.345	1.56	2.5	2.43 x 10^{21}
10 – 2	0.458	2.30	1.7	2.84 x10^{21}

$$N_e\,[m^{-3}] = 8.0\;x\;10^{18}\left(\frac{w\,[\text{Å}]}{\alpha_{1/2}^{n}}\right)^{3/2} \quad (3)$$

With the instrumental FWHM of 0.03 nm, and assuming gas temperature $T_g \approx T_{exc}$, (where electron excitation temperature T_{exc} = 9000 K is determined from the Boltzmann plot of Ar I spectral lines), the Gaussian w_g part of line profiles is estimated, see Table 1. The comparison of the Gaussian part with the total line width shows that it may be neglected. The comparison of the N_e = 2.54 x 10^{21} m^{-3} determined from the H_β profile in Fig.1. and values 1.4 to 2.9 x 10^{21} m^{-3} (11 $< n_{max} <$ 10) estimated by Eq.1a, with those in Table 2 shows that widths of the H_6 - H_{10} lines can be used with a reasonable accuracy ± 12 - 15% for N_e diagnostics.

The interference with molecular bands causes the main difficulty for application of these lines, see example in Figure 4 . Besides facts that the end - on recorded spectral line shapes of helium lines and Balmer lines are distorted due to superposition of line profiles emitted from layers with different plasma parameters, the determined electron densities from H_β: N_e = 3.1; H_δ: N_e = 3.9; He I 447.1: N_e = 3.1; and HeI 492.2 nm (see Fig 5b): N_e = 3.4 x 10^{20} m^{-3} are in a good agreement.

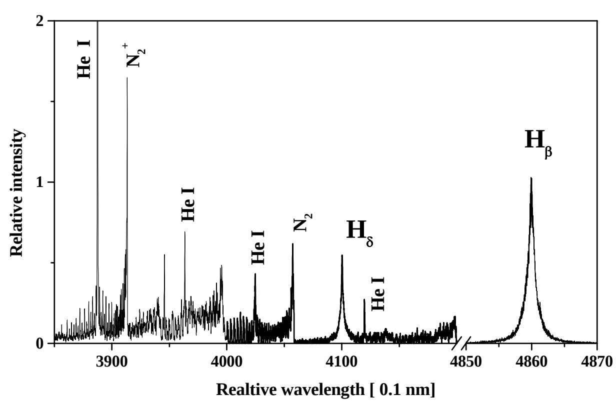

FIGURE 4. Spectra recordings from open capillary MIP at atmospheric pressure; Power input 100 W and flow rate of He 0.7 l/min

3.4. Helium lines with Forbidden Component

In the case of helium plasmas, electron density can be determined by using the shape of some visible He I lines with forbidden components. The complex structures of these lines are extensively studied both theoretically and experimentally.The inclusion of ion dynamic effects in theoretical descriptions of helium lines with forbidden components greatly improves agreement with experimental results. However, the discrepancy of predicted forbidden line intensity with the experiment [17] still remains for all three theoretical approaches. This is a main reason why experimentally determined formulas relating N_e with the parameters of helium lines with forbidden component such as F/A - forbidden (F) to allowed (A) line maximum intensity, D/A - deep (D) i.e. minimum intensity between forbidden and allowed line and A line intensity) and *s* - wavelength separation between F and A determined by Czernichowski and Chapelle [18] are mainly used. Due to the fact that parameter *s* is not sensitive to distortion of the strong allowed line due to the possible presence of a self-absorption effect, the following relation was used in this work

$$\log N_e\,[m^{-3}] = 23.056 + 1.586 \log (s[nm] - 0.156) + 0.225\, [\log (s - 0.156)]^2 \qquad (5)$$

where 0.156 nm in Eq.(6) is the separation between unperturbed F and A line.

This procedure can be applied for low N_e determination, but for more precise F and s determination, with a different amplification when recording forbidden or allow component must be used, see Fig.5a. It should be pointed out that great care must be also taken when using He I lines with forbidden components for the determination of N_e lower than few times 10^{14} [cm^{-3}]. At these densities, the low intensity of the forbidden component (less than few percents of the allowed one), may be masked by noise or in presence of nitrogen by molecular lines from 6-8 and 8-10 bands of the first negative system of N_2^+.

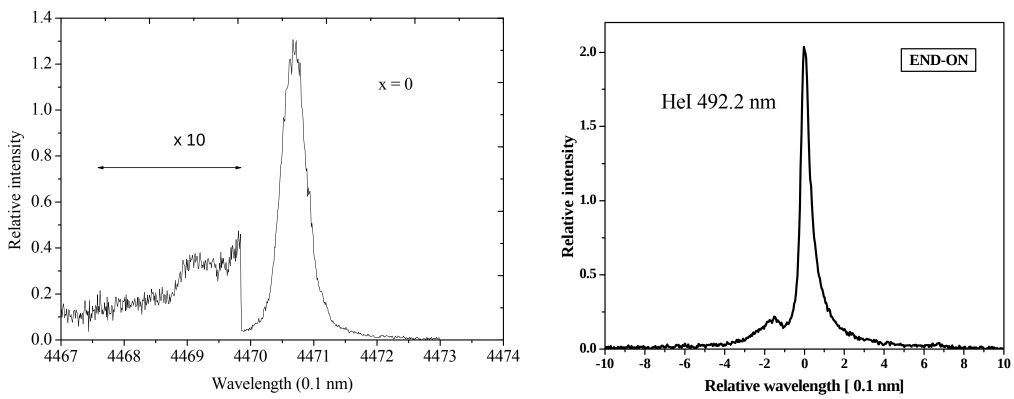

FIGURE 5. a) Illustration of line shape recording with different amplification of the signal. Line emitted from the center of the Mini MIP at height 1mm from the torch orriface. The flow rate of He was 0.6 l/min, and He+ 3% H_2 0.2 l/min through the outer and inner capillary. b) Same as in Fig.4.

3.5. Intensity of the N_2 and N_2^+ Molecular Band Heads

According to [19-21], the electron density in nitrogen and nitrogen/He plasmas can be determined from the intensity of N_2 second positive system (SPS) band head (0-0) at 337.1 nm ($C\ ^3\Pi_u \rightarrow B\ ^3\Pi_g$) and N_2^+ first negative system (FNS) band head of (0-0) at 391.4 nm ($B^2\Sigma_u^+ \rightarrow X^2\Sigma_g^+$).

Namely, by using the simplified kinetic model of the N_2 ($C^3\Pi_u$) state, see e.g. [20] and assuming that the steady-state population of the upper energy state is equal zero, a linear relation between the 337.1 nm band intensity and the electron density at constant pressure and constant electric field may be obtained. This relation is confirmed with 5% accuracy in a volumetric near field microwave plasma [21].

A similar discussion can be applied to the band head of FNSystem of nitrogen ion [20]. Due to an additional excitation process for the upper level population, the intensity of the 391.4 nm line has quadratic dependence upon electron density, i.e. $I_{(391.4\ nm)} \sim N_u \sim A\ N_e^2 + B\ N_e$, where N_u is the population of the $B^2\Sigma_u^+$ state, while A and B are constants, which must be independently determined. According to the authors [19], this method can be applied even in plasmas with non-Maxwellian electron energy distribution.

The band head intensity method is tested in MIP at atmospheric pressure with power input of 100 W and at constant He flow rate of 0.7 l/min. The radial distributions of the band head intensities and hydrogen Balmer beta line shapes – H_β are obtained by Abel inversion procedure from lateral side-on recordings. From the determined H_β line shapes electron densities are calculated using approximate experimental formula, see Eq.2. Finally, dependence of the molecular nitrogen band head intensities versus log N_e for different values of radius are presented in Figure 6.

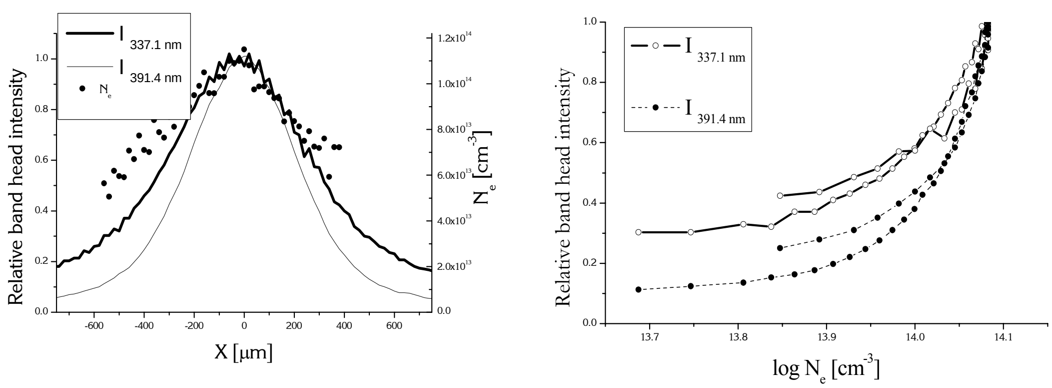

FIGURE 6. a) Radial dependence of the molecular nitrogen band head intensities and N_e and b) dependence of the band head intensities versus log N_e for different values of radius, in MIP at atmospheric pressure; Power input 100 W and flow rate of He 0.7 l/min

It is evident that the application of this method for N_e determination requires further elaboration and experimental verifications in different plasma sources and gas mixtures. It should be noticed that the calibration of log N_2 band intensity vs. log N_e determined using another independent diagnostic technique enables slope parameter determination. The extrapolation of intensity vs. N_e plot may be used for lower N_e plasma diagnostics.

4. CONCLUSIONS

The use of the Balmer beta line is still a best method till the low electron densities, when the influence of other broadening mechanism and fine structure splitting became important. In that case other analyzed methods can be favorable.

The techniques based on line series merging is still attractive especially at very low densities, but in cases when interfering lines are weak or absent.

The use of Stark FWHM of higher members of Balmer series is simple and successfully applied even in diagnostics of tokamak plasmas [22], but is always accompanied with relatively large uncertainty of $\alpha_{1/2}^{n}$ parameter; see Table 1in [16]. In order to increase accuracy of the use of higher members of Balmer series numerical procedure for electron density determination by fitting whole experimental profiles of hydrogen Balmer series with theoretical ones is under development.

The helium lines with forbidden components can be used in a very broad range of electron densities and even at lower than 10^{15} cm^{-3}. However, for lower electron density diagnostics the more complicated procedure must be used and further theoretical studies will be welcomed.

It should be stressed out that the molecular nitrogen band heads intensities offer a greatest possibility for diagnostics of very lower densities, but both theoretical and experimental studies in different plasma conditions are needed.

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Eds. M. M. Kuraica and B. M. Obradović

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INVITED LECTURES

ORAL LECTURES

ON THE APPLICATION OF OPTICAL EMISSION SPECTROSCOPY FOR LOW ELECTRON DENSITY PLASMA DIAGNOSTICS

N. Konjević[1] and M. Ivković[2]

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1. INTRODUCTION

Since the electron number density, N_e, is related directly or indirectly to most of plasma components and processes, N_e. is one of the most important parameters required for plasma characterization and for testing of plasma modeling. This is why numerous diagnostic techniques for plasma N_e measurement were developed. Apart from microwave interferometry [1], infrared and visible interferometry was considerably improved after the discovery of lasers, see e.g. [2]. Diagnostic technique based on Thomson scattering of laser radiation on free plasma electrons is frequently and efficiently used for N_e diagnostics as well, see e.g. [3]. Parallel with the development of new or improved microwave and laser interferometry techniques for the same purpose Optical Emission Spectroscopy (OES) techniques were improved permanently for the last fifty years, see e.g. [4]. The main reason for the interest for OES techniques: no plasma perturbation, high spatial resolution, requires relatively simple low cost equipment easy to set up outdoors and usually available in laboratory and finally the OES technique may be applied to study distant plasmas like e.g. in astrophysics.

2. SHORT DESCRIPTION OF THE LECTURE

Since the requirements for N_e diagnostics in the field of plasma chemistry are mainly in relatively low electron density region, $N_e < 10^{15}$ cm^{-3}, we focus our report to the developments OES diagnostics for these plasma densities. Apart from several examples of OES techniques based on the measurement of spectral line intensities most of this report is devoted to the application of hydrogen line shapes suitable for low N_e diagnostics. Since the shapes of non-hydrogenic lines due to the quadratic Stark effect are useful for plasma diagnostics for $N_e > 10^{15}$ cm^{-3}, see e.g. [5, 6] we concentrate here to hydrogen lines with linear Stark effect, which are sensitive enough to be used for diagnostics of low electron densities.

For correct application of the OES diagnostic techniques numerous precautions have to be carried out. These are primarily related to the estimation of other broadening mechanisms, deconvolution procedure, self -absorption effect etc. The estimation of all these interference effects with measured line profile and correction for their influence is of crucial importance for correct application of OES technique. Therefore, the procedure of treating experimental profile to separate Stark broadening from other broadening mechanisms will be discussed in some detail. Here, we shall draw attention to newly applied technique for detection of self-absorption in pulsed water discharge used recently in the study of Plasma Electrolytic Oxidation (PEO) of tantalum and aluminum [7, 8].

This will be followed by an overview of recent work on low N_e diagnostics using partial local thermal equilibrium criterion [9] and line Stark widths along spectral series [10,11]. Special attention will be focused on the application of the first three Balmer lines for N_e diagnostics. The use of the H_α and the H_β experimental line profiles in conjunction with theoretical profiles and various approximate formulas will be analyzed and discussed. This is in particular related to applications at $N_e < 10^{14}$ cm^{-3} since fine structure splitting of hydrogen lines is not taken into account and, therefore, none of the theoretical calculations may be applied with confidence for so low electron densities. The validity of various approximations used to extend the application of theoretical data for the H_α and the H_β line below $N_e \approx 10^{14}$ cm^{-3} will be discussed.

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09:30-09:50	*Electron attachment to unstable molecules* **Tom Field,** Queen's University of Belfast, Belfast, UK	
09:50-10:10	*Dissociative electron attachment studies with potential radiosensitizers* **Stephan Denifl,** University of Innsbruck, Institute of Ion Physics, Innsbruck, Austria	
10:10-10:30	*(Time-dependent) Density Functional Theory for understanding dissociative chemistry of organometallic compounds* **Matija Zlatar,** Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia	
10:30-11:00	***Coffee break***	
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11:20-11:40	*Role of symmetry lowering in DEA* **Juraj Fedor,** Department of Chemistry, University of Fribourg, Fribourg, Switzerland	
11:40-12:00	*Velocity slice imaging study on dissociative electron attachment* **Ewelina Szymanska,** Department of Physical Sciences, The Open University, Milton Keynes, UK	
12:00-12:20	*Theoretical treatment of dissociative electron attachment* **Peter Papp,** Comenius University, Bratislava, Slovakia	
12:20-13:50	***Lunch break (&registration)***	
	XiBiGP Workshop	***NonEqProc Workshop***
13:50-14:00	Opening and Introduction Christophe Nicolas (SOLEIL synchrotron)	Opening and Introduction Zoran Lj. Petrovic (SASA)
	Session 1, Hall A *Chair: Christophe Nicolas*	***Session 1, Hall B*** *Chair: Saša Dujko*
14:00-14:30	*Study of single photon multiple ionization processes with a magnetic bottle spectrometer* **Pascal Lablanquie,** LCP-MR CNRS & Université Paris VI, Paris, France	*Non-equilibrium transport of charged particles in gaseous and disordered materials* **Ron White,** ARC Centre of Excellence for Antimatter-Matter Studies, James Cook University, Townsville, Australia
14:30-15:00	*Synchrotron radiation studies of biomolecules: photoabsorption, and core and valence photoionization* **Kevin Prince,** Sincrotrone Trieste, Trieste, Italy	*First principles calculation of the effect of Coulomb collisions on electron swarms* **Zoltan Donko,** Wigner Research Centre for Physics, Hungarian Academy of Sciences, Budapest, Hungary
15:00-15:30	*Electron-ion coincidence spectroscopy as a tool to study radiation-induced molecular dynamics* **Edwin Kukk,** Department of Physics and Astronomy, University of Turku, Turku, Finland	*Recent progress in the Newtonian three-body problem* **Veljko Dmitrašinović and Milovan Šuvakov,** Institute of Physics, Belgrade, Serbia

	Parallel session A5, *Chair: Goran Poparić*	***Parallel session B5,*** *Chair: Milivoje Ivković*
14:30-14:50	*Electron transfer upon potassium collisions with biomolecules* **Filipe Ferreira da Silva,** *Universidade Nova de Lisboa, Portugal*	*Electrical breakdowns in air: new experiments and statistical and numerical models* **Aleksandar Jovanović,** University of Niš, Serbia
14:50-15:10	*Absolute differential cross sections for elastic electron scattering from small biomolecules* **Jelena Maljković ,** Institute of Physics, University of Belgrade, Belgrade, Serbia	*Spectroscopic study of plasma during electrolytic oxidation of magnesium-aluminium alloys* **Jovica Jovović,** Faculty of Physics, University of Belgrade, Belgrade, Serbia
15:10-15:30	*Electron – Indium atom scattering and analysis of electron and optical spectra* **Maja Rabasović,** Institute of Physics, University of Belgrade, Belgrade, Serbia	*Measurements and models of transient and stationary regimes of glow discharge in argon* **Marjan Stankov,** University of Niš, Niš, Serbia
15:30-15:50	*Single electron capture in fast ion-atom collisions* **Nenad Milojević,** University of Niš, Serbia	*Diagnostics of Laser induced plasma by optical emission spectroscopy* **Marko Cvejić,** Institute of Physics, University of Belgrade, Belgrade, Serbia
15:50-16:30	***Coffee break***	
	Parallel session A6, *Chair: Zoltan Donkó*	***Parallel session B6,*** *Chair: Nenad Simonović*
(A) 16:30-16:50 (B) 16:30-17:00	*Electron heating dynamics in multi-frequency capacitive RF discharges* **Aranka Derzsi,** Hungarian academy of sciences, Budapest, Hungary	*Electron excitation and autoinization cross sections for elements of chemically peculiar (CP) stars: Study of bismuth* **Branko Predojević,** University of Banja Luka, Banja Luka, Repubika Srpska, B&H
(A) 16:50-17:10 (B) 17:00-17:20	*Simulation and modeling of Resistive Plate Chambers* **Danko Bošnjaković,** Institute of Physics, University of Belgrade, Belgrade, Serbia	*Wake effect in graphene due to moving charged particles* **Ivan Radović,** VINCA Institute of Nuclear Sciences, Belgrade, Serbia
(A) 17:10-17:30 (B) 17:20-17:40	*The non-symmetric ion-atom absorption processes in the helium rich white dwarf atmospheres in UV and EUV region* **Vladimir Srećković,** Institute of Physics, University of Belgrade, Belgrade, Serbia	*Interaction of charged particles with capillaries* **Károly Tőkési,** Institute for Nuclear Research, Hungarian Academy of Sciences, Debrecen, Hungary
	Free time	
20:00	***Gathering and transport to Danube quay***	
20:30 -	***Conference dinner and Closing***	

Saturday 30th August 2014	
10:00-17:00	***Excursions (optional, info at registration desk)***
17:00	***Departure***

Completed Reviewer Assignments for Milivoje Ivkovic, Ph.D

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View Review Comments View Decision Letter Send E-mail	1	GL2968	Regular Paper	Diagnostics of inhomogeneous plasma : Correction coefficients of the self-absorption and of the effect of spatial inhomogeneity	May 08, 2015	May 10, 2015	May 31, 2015	Jun 05, 2015	28	Hssaïne AMAMOU, Ph.D.
View Review Comments View Decision Letter Send E-mail	2	NOEES903R1	Regular Paper	Measuring the electron density in plasmas from the difference of Lorentzian part of the widths of two Balmer series hydrogen lines	Sep 21, 2014	Oct 03, 2014	Sep 26, 2014	Oct 03, 2014	12	Maria Carmen Garcia, Ph.D.
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View Review Comments View Decision Letter Send E-mail	2	GL2706	Regular Paper	Spectroscopic Study of the Plasma Generated in the Formation of WCN Thin Coatings, Grown by the Pulsed Vacuum Arc Technique	Jul 17, 2013	Jul 17, 2013	Aug 07, 2013	Aug 08, 2013	22	Elisabeth Restrepo-Parra, Prof.

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Milivoje ivkovic | My Journals | Log Out | Help EVISE

Journal of Quantitative Spectroscopy & Radiative Transfer

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Dear Dr. Ivkovic:

Thank you for reviewing manuscript # TPS4986 entitled "A Minimally Destructive Multi-element Sensing Technique for Metal Alloys by Laser-induced Breakdown Spectroscopy" for the IEEE Transactions on Plasma Science.

On behalf of the Editors of the IEEE Transactions on Plasma Science, we appreciate the voluntary contribution that each reviewer gives to the Journal. We thank you for your participation in the online review process and hope that we may call upon you again to review future manuscripts.

Sincerely,
Prof. Mark Gilmore
Editor, IEEE Transactions on Plasma Science

Message 311 of 519

Институт за физику, Универзитет у Београду
Прегревица 118, 11080 Београд

Др Миливоје Ивковић
Виши научни сарадник
Институт за физику, Универзитет у Београду
Прегревица 118, 11080 Београд

Предмет: Потврда о координаторству темом у оквиру научноистраживачког пројекта Министарства просвете, науке и технолошког развоја ОИ 141032 – "*Нискотемпературна плазма и пражњења: Радијациона својства и интеракција са површинама*".

Потврђујем да је др Миливоје Ивковић, виши научни сарадник, запослен у Институту з афизику Универзитета у Београду, у пројектном циклусу 2006 – 2010. године коруководио темом: *"Спектралне линије водоника и хелијумове линије са забрањеним компонетама за дијагностику плазме"*, у оквиру научно истраживачког пројекта основних истраживања *"Нискотемпературна плазма и пражњења: Радијациона својства и интеракција са површинама"*, евиденциони број ОИ141036.

Пројекат *"Нискотемпературна плазма и пражњења: Радијациона својства и интеракција са површинама"* предмет је **Уговора о реализацији и финансирању научноистраживачког пројекта и одржавања научноистраживачке опреме и простора за научноистраживачки рад**, за циклус истраживања у периоду 2006 – 2010.

Београд, 25.11.2015.

Руководилац пројекта

Др Никола Коњевић
Професор емеритус
Физичког факултета Универзитета у Београду
и редовни члан Српске Академије Наука и Уметности

Институт за физику, Универзитет у Београду
Прегревица 118, 11080 Београд

Др Миливоје Ивковић
Виши научни сарадник
Институт за физику, Универзитет у Београду
Прегревица 118, 11080 Београд

Предмет: Потврда о коруковођењу темом у оквиру научноистраживачког пројекта Министарства просвете, науке и технолошког развоја ОИ 171014 – *"Спектроскопска дијагностика нискотемпературне плазме и гасних пражњења: облици спектралних линија и интеракција са површинама*".

Потврђујем да је др Миливоје Ивковић, виши научни сарадник, запослен у Институту за физику Универзитета у Београду, у пројектном циклусу 2011 – 2015. године коруководио темом: *"Спектралне линије водоника и хелијумове линије са забрањеним компонентама за дијагностику плазме"*, у оквиру научно истраживачког пројекта основних истраживања "*Спектроскопска дијагностика нискотемпературне плазме и гасних пражњења: облици спектралних линија и интеракција са површинама"*, евиденциони број ОИ171032.

Пројекат "*Спектроскопска дијагностика нискотемпературне плазме и гасних пражњења: облици спектралних линија и интеракција са површинама"* предмет је **Уговора о реализацији и финансирању научноистраживачког пројекта и одржавања научноистраживачке опреме и простора за научноистраживачки рад**, за циклус истраживања у периоду 2011 – 2015.

Београд, 25.11.2015.

Руководилац пројекта

Др Соња Јовићевић
Научни саветник
Институт за физику, Универзитет у Београду

Природно-математички факултет
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П О Т В Р Д А

Којом се потврђује од стране Природно-математичког факултета у Новом Саду да је **МР ТЕОДОРА ГАЈО,** дана 10. јула 2015. године пријавила тему докторске дисертације под насловом**: "Померај спектралних линија хелијума у густој нискотемпературској плазми".**

Наставно-научно веће факултета прихватило је тему на ванредној седници одржаној 08. септембра 2015. године.

На 1. седници од 22. октобра 2015., Сенат Унивезитета дао је сагласност за подобност теме **"Померај спектралних линија хелијума у густој нискотемпературској плазми",** кандидата мр Теодоре Гајо и ментора др Миливоја Ивковића, вишег научног сарадника Института за физику у Београду.

Шеф одсека за опште и студентеке послове

Тамара Зорић, дипл.правник

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УГОВОР О ДЕЛУ

Закључили су:

1. **Универзитет у Београду-Електротехнички факултет**, Београд, Булевар краља Александра бр.73, кога заступа декан проф.др Бранко Ковачевић (у даљем тексту: НАРУЧИЛАЦ), и

2. **Др Миливоје (Радисав) Ивковић**, запослена на Институту за физику Земун - Београд, из Београда, ул. Моравичка 9, Општина Вождовац, ЈМБГ: 2211956710136, бр.рачуна: 200-2876027-91 , отворен код Поштанске штедионице а.д. Београд, (у даљем тексту: ПОСЛЕНИК).

Члан 1.

Предмет уговора је:
1.Учешће у изради завршног рада (магистарски, **мастер**, докторски) **и то:**
а) руковођење израдом рада – менторство,
б) учешће у комисији за прихватање теме,
ц) писање извештаја за прихватање теме,
д) учешће у Комисији за преглед и оцену рада,
е) писање извештаја о прегледу и оцени рада,
ф) учешће у Комисији за усмену одбрану рада
кандидата Ане Драгојловић.

Члан 2.

Посленик ће активности из члана 1 које представљају предмет уговора обавити у току школске 2014/2015. године.

Члан 3.

Посленик има право за надокнаду за извршени рад по овом уговору према Правилнику о раду, а на основу овереног извештаја продекана за наставу.

Члан 4.

Уговор ступа на снагу даном закључивања.

Члан 5.

Уговорне стране ће све евентуалне спорове решавати споразумно, а уколико то није могуће надлежан је Први основни суд у Београду.

Члан 6.

Овај Уговор је сачињен у 3 (три) истоветна примерка од којих 2 (два) задржава Наручилац а један Посленик.

НАРУЧИЛАЦ
Декан

ПОСЛЕНИК
Др Миливоје Ивковић

Univerzitet u Beogradu

Fakultet za fizičku hemiju

Ispitivanje laserom indukovane plazme u atmosferi argona

Diplomski rad

Student

Milica Vinić

Mentor

Miroslav Kuzmanović

Beograd, jul 2012.

Ovaj rad je realizovan u laboratoriji za spektroskopiju plazme i fiziku lasera u Institutu za fiziku u Zemunu. Rukovodilac rada bio je dr Milivoje Ivković, naučni saradnik Instituta za fiziku.

Ovom prilikom želim da se zahvalim mentoru ovog rada, dr Miroslavu Kuzmanoviću, koji je omogućio izbor željene teme.

Veliku zahvalnost želim izraziti dr Milivoju Ivkoviću na uloženom trudu, radu i vremenu, nesebičnoj pomoći i moralnoj podršci čime je omogućio uspešnu izradu ovog rada.

Svoju zahvalnost dugujem i Stanku Milanoviću, višem tehničkom saradniku, na pomoći pri postavci eksperimenta. Njegovo angažovanje je bilo dragoceno prilikom rada sa visokim naponom.

Univerzitet u Beogradu
Fakultet za fizičku hemiju

Mogućnosti primene spektroskopije laserom indukovanog proboja, za analizu zemljišta

Master rad

Mentori:
Milivoje Ivković
Miroslav Kuzmanović

Student:
Milica Vinić

Beograd, jul 2013.

Ovaj rad je realizovan u Laboratoriji za spektroskopiju plazme i lasere Instituta za fiziku u Zemunu pod rukovodstvom dr Milivoja Ivkovića, višeg naučnog saradnika Instituta za fiziku.

Ovom prilikom želim da se zahvalim mentoru rada, dr Miroslavu Kuzmanoviću, koji je omogućio izbor željene teme i znatno doprineo kvalitetu ovog master rada.

Veliku zahvalnost želim izraziti dr Milivoju Ivkoviću na uloženom trudu, radu i vremenu, nesebičnoj pomoći i moralnoj podršci čime je omogućio uspešnu izradu ovog rada.

Svoju zahvalnost dugujem i Stanku Milanoviću, višem tehničkom saradniku, na pomoći pri postavci eksperimenta. Njegovo angažovanje je bilo dragoceno prilikom rada sa visokim naponom.

Takođe, želim da se zahvalim dr Miroslavu Kuzmanoviću i dr Jeleni Savović na uzorcima različitih zemljišta i omogućavanju njihove analize na ISP-OES u Laboratoriji za fizičku hemiju Instituta za nuklearne nauke u Vinči.

Z A P I S N I K
sa X sednice Naučno-nastavnog veća održane u sredu 20. juna 2007. godine

Sednici prisustvuje 47 članova Naučno-nastavnog veća.

Službeno odsutni: prof. dr Goran Škoro
doc. dr Edib Dobardžić
doc. dr Vladimir Milosavljević
doc. dr Ivan Videnović
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prof. dr Dragomir Krpić
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Dekan Fakulteta prof. dr Ljubiša Zeković otvorio je sednicu u 11:20 časova i predložio sledeći

D n e v n i r e d

1. Usvajanje Zapisnika sa IX sednice Naučno-nastavnog veća.
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    a) mr VLADIMIRA JOVANOVIĆA, diplomiranog fizičara, koji je prijavio doktorsku disertaciju pod nazivom: «PROUČAVANJE ELEKTRONSKOG TRANSPORTA U SUPERPROVODNIM FILMOVIMA SA VISOKOM KRITIČNOM TEMPERATUROM U FUNKCIJI DOPIRANJA»
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    a) mr DJORDJA STRATIMIROVIĆA, diplomiranog fizičara, koji je predao doktorsku disertaciju pod nazivom: «PRIMENA VEJVLET TRANSFORMACIJA PRI STATISTIČKOJ ANALIZI VREMENSKIH SERIJA STIMULISANE DINAMIKE FUZIMOTORNIH NEURONA»
    b) mr MIHAJLA RABASOVIĆA, diplomiranog fizičara, koji je predao doktorsku disertaciju pod nazivom: «ODREĐIVANJE PROSTORNOG PROFILA LASERSKOG ZRAČENJA IMPULSNOM FOTOAKUSTIKOM U GASNIM SMEŠAMA»
4. Usvajanje Izveštaja Komisije za pregled i ocenu doktorske disertacije i odredjivanje Komisije za odbranu disertacije za:

a) mr BOŽIDARA NIKOLIĆA, diplomiranog fizičara, koji je predao doktorsku disertaciju pod nazivom: «RAMANOVO RASEJANJE NA JEDNOSLOJNIM UGLJENIČNIM NANOTUBAMA»
Komisija: *prof. dr Milan Damnjanović*
prof. dr Ivanka Milošević
dr Radmila Kostić

5. tačka

Usvojena je prijavljena tema za izradu magistarske teze i odredjen mentor za:
a) IVANA KORALTA, diplomiranog fizičara, koji je prijavio magistarsku tezu pod nazivom: «ISTRAŽIVANJE OBLIKA BALMEROVIH LINIJA VODONIKA U PLAZMI PRI NISKIM ELEKTRONSKIM KONCENTRACIJAMA»
Mentori: *dr Milivoje Ivković*
prof. dr Nikola Konjević

b) DEJANA ĐOKIĆA, diplomiranog fizičara, koji je prijavio magistarsku tezu pod nazivom: «UTICAJ SPINSKIH KORELACIJA NA INFRACRVENU AKTIVNU OPTIČKU MODU ANTIFEROMAGNETA α-MnSe»
Mentor: *prof. dr Zoran Popović*

6. tačka

Odredjena je Komisija za pregled i ocenu magistarske teze za:
a) NENADA VRANJEŠA, diplomiranog fizičara, koji je predao magistarsku tezu pod nazivom: «MOGUĆNOSTI ATLAS DETEKTORA ZA MERENJE PRODUKCIJE PAROVA W BOZONA NA VELIKOM HADRONSKOM KOLAJDERU»
Komisija: *dr Ljiljana Simić*
prof. dr Dragomir Krpić
prof. dr Ivan Aničin

b) OLJU ĐORĐIĆ, diplomiranog fizičara, koja je predala magistarsku tezu pod nazivom: «DVOČESTIČNE AZIMUTALNE KORELACIJE I TOK PROTONA I PIONA U C+Ta SUDARIMA NA ENERGIJI 4.2A GeV»
Komisija: *dr Ljiljana Simić*
prof. dr Dragomir Krpić
prof. dr Ivan Aničin

c) ALEKSANDRA KRMPOTA, diplomiranog fizičara, koji je predao magistarsku tezu pod nazivom: «ELEKTROMAGNETNO INDUKOVANA TRANSPARENCIJA I APSORPCIJA PRILIKOM INTERAKCIJE DVOHROMATSKOG KOHERENTNOG ZRAČENJA SA ATOMIMA RUBIDIJUMA»

Course No.3

Course Name: Gas laser technology

Prof. Dr. Milivoje Ivkovic

L. No	Lecture title	Duration Time	Date
1	**Lecture 1 Fundamentals of the gas discharges types and corresponding gas lasers**	2 hours	15.06.2009.
2	**Lecture 2 Problems in gas laser production**	4 hours	16.06.2009.
3	**Lecture 3 He-Ne lasers**	2 hours	17.06.2009.
4	**Lecture 4 Noble gas ion lasers: Ar. Kr**	2 hours	18.06.2009.
5	**Lecture 5 Metal vapor lasers: Cd, Se, Au, Cu.**	2 hours	19.06.2009.
	Day off		
	Day off		
6	**Lecture 6 CO2 and CO lasers**	4 hours	22.06.2009.
7	**Lecture 7 High power CO2 lasers.**	2 hours	23.06.2009.
8	**Lecture 8 Pulsed lasers**	4 hours	24.06.2009.
9	**Lecture 9 Gas dynamic lasers. Chemical lasers**	2 hours	25.06.2009.
10	**Lecture 10 Beam manipulation**	2 hours	26.06.2009.

Notes

- All lectures start at 10 am,
- Duration of each lecture is either 2 school hours (90 min) or 4 school hours (180 min).

Syllabus for the gas laser technology

The course Gas laser technology is multidiscipline course on fundamental principles, maintains and construction problems of various gas lasers. Within this course students will learn fundamental physical principles of: creation of inverse population for each gas laser type, Gas discharge physics, laser tube construction i.e. components, material selection, problems...power supply design and output beam characteristics and application.

Lecture 1. Fundamentals of the gas discharges types and corresponding gas lasers

Lecture covers: description of differences between solid state and gas lasers and fundamentals of different gas discharges (glow, hollow cathode, arcs, RF, pulsed…) and their corresponding type or category according to: gas flow conditions (sealed, slow flow, fast flow and gas dynamic lasers), gas pressure (low and high pressure lasers) and excitation conditions (CW and pulsed lasers).

Lecture 2. Problems in gas laser production

Lecture covers detailed description and solution of common problems of all gas lasers such as: material selection, vacuum (sealing), gas handling (decomposition), and power supplies…Solution of problems will de demonstrated during additional practical hours.

Lecture 3. He-Ne lasers

Lecture covers fundamentals of glow discharge physics: voltage and electric field distribution, cathode dark space, Faraday dark space, negative glow, positive column. Laser tube construction, components (electrodes, mirrors, getter...). Pressure and gas mixture ratio determination, line selection, principles of power supply construction and current optimization will be analyzed also.

Lecture 4. Noble gas ion lasers: Ar. Kr

Lecture covers fundamentals of creation of inverse population in ion lasers and basic physics of arc discharge: Principles of laser tube construction including hot cathode i.e. thermo ionic emission physics, role of magnets, gas return path… Analysis of line selection, current and light stabilization and maintains problems (tube degradation, refilling) are also included.

Lecture 5. Metal vapor lasers: Cd, Se, Au, Cu.

Lecture covers fundamentals of creation of inverse population in metal vapor lasers and basic physics of hollow cathode discharge. Details of laser construction

Lecture 6. CO2 and CO lasers

Lecture covers fundamentals of creation of inverse population in molecular gas lasers and basic physics of positive column of the glow discharge and RF discharges. Various types of CO2 lasers will be analyzed and some of them demonstrated during practical hours.

Lecture 7. High power CO2 lasers

Lecture covers fundamentals of power scaling, cooling problems and construction principles of different high power CO2 lasers (slow and fast flow, longitudinal and transversal, slab and annular) types.

Lecture 8. Pulsed lasers

Lecture covers fundamentals of pulse laser construction and physics of inverse population creation in nitrogen and excimer lasers. Different pulsed plasma sources, solutions for discharge preionization and different switching devices as well as electrode construction will be demonstrated during additional practical part of course.

Lecture 9. Gas dynamic lasers. Chemical lasers

Lecture covers fundamentals of creation of inverse population gas dynamic and chemical lasers and basic physics of theirs work.

Lecture 10. Beam manipulation

Lecture covers fundamentals of transversal and longitudinal mode selection and control. Output beam handling: fibers, waveguides, articulated arms, scanning devices will be analyzed also. Basic principles of Q-switching, Faraday isolation, harmonic generation… will be presented and demonstrated during theoretical and additional practical part of course.

INSTITUT ZA FIZIKU — INSTITUTE OF PHYSICS
P.O. Box 68, 11080 Beograd - Srbija, Tel. +381 (11) 3713 000, Fax. +381 (011) 3162 190

РЕПУБЛИКА СРБИЈА
УНИВЕРЗИТЕТ У БЕОГРАДУ
ИНСТИТУТ ЗА ФИЗИКУ
0801 Бр. 1206/3
15 SEP 2009 год.

УНИВЕРЗИТЕТ У НОВОМ САДУ
ПРИРОДНО-МАТЕМАТИЧКИ ФАКУЛТЕТ
ДЕКАНАТ
Нови Сад, Трг Доситеја Обрадовића бр. 3

ПРЕДМЕТ: Сагласност за рад истраживача на ПМФ Нови Сад

На основу вашег Захтева број: 0601-55/142 од 17.082009. године, **дајемо сагласност** да на основу чл. 75. и 69. ст.2. Закона о високом образовању, чл.89. Закона о научно-истраживачкој делатности и чл. 202. Закона о раду да истраживачи:

ДР АНТУН БАЛАЖ, за извођење наставе из предмета *Увод у теорију поља* и *Економска физика*;

ДР МИЛИВОЈЕ ИВКОВИЋ, за извођење наставе из предмета *Оптички и оптометријски инструменти*,
на Природно-математичком факулету у Новом Саду, у школској 2009/2010. години.

С поштовањем,

ДИРЕКТОР ИНСТИТУТА ЗА ФИЗИКУ
Др Драган Поповић

РЕПУБЛИКА СРБИЈА УНИВЕРЗИТЕТ У БЕОГРАДУ ИНСТИТУТ ЗА ФИЗИКУ

INSTITUT ZA FIZIKU
11001 Beograd - Yugoslavia, P.O. Box 57.
INSTITUTE OF PHYSICS
Tel. +381 (11) 3160 260, Fax. +381 (011) 3162 190

РЕПУБЛИКА СРБИЈА
УНИВЕРЗИТЕТ У БЕОГРАДУ
ИНСТИТУТ ЗА ФИЗИКУ
0801 Бр. 1332/1
01. 11. 2006 год.

MINISTERIO DE CIENCIA Y TECNOLOGÍA
Secretaría de Estado de Polítíca Científica y Tecnológica
Direccion General de Investigación

SUBJECT: Agreement for participation to the project

The Institute of Physics of the University of Belgrade fully support the research within the project

"Spectroscopy diagnosis of plasmas at very high and very low density

"Diagnosis espectroscópica en plasmas de muy alta y muy baja densidad"

The project leader and first investigator from the Institute of Physics side is Prof.Dr.Nikola Konjevic and second and third investigators are Dr.Sonja Jovicevic and Dr.Milivoje Ivkovic.

Belgrade, October 31th 2006

Approved by:

РЕПУБЛИКА СРБИЈА УНИВЕРЗИТЕТ У БЕОГРАДУ ИНСТИТУТ ЗА ФИЗИКУ

Director of Institute of Physics
Prof. Dr. Dragan Popovic

Institute of Physics

Serbia & Montenegro

National Institute for Lasers, Plasma and Radiation Physics

Romania

РЕПУБЛИКА СРБИЈА
УНИВЕРЗИТЕТ У БЕОГРАДУ
ИНСТИТУТ ЗА ФИЗИКУ
0801 Бр. 190/1 2006.
20.02. 199 год.

INSTITUTUL NATIONAL DE CERCETARE - DEZVOLTARE PENTRU FIZICA LASERILOR, PLASMEI SI RADIATIEI
Iesire
NR. 570 data 21.02.2006

Scientific and Technological Bilateral Agreement

in the field of

Advanced laser plasma studies: spectroscopic diagnostics and applications in thin films deposition and characterizations

Background:

Lasers and plasma spectroscopy laboratory, Institute of Physics

Experience: more than 30 years in plasma spectroscopy and lasers. Critical reviews and publications in peer review journals. The research is related with fundamental studies and applications of line shapes for plasma diagnostics. Low-temperature plasma experience. Hydrogenic and non-hydrogenic line shapes. Optical emission spectroscopy techniques are studied. Long experience in the field of continuous waves and pulsed discharges spectroscopy.

"Laser-Surface-Plasma Interactions" Laboratory, a Lasers Department unit, has more than 35 years of experience in the field of laser generated plasmas, laser-surface interactions, and materials processing with lasers. In the last 10 years, the activity was mainly focused on laser interactions (theoretical and experimental), synthesis and deposition of compound thin films using UV laser sources by Pulsed Laser Deposition (PLD) in inert or chemically active (reactive PLD) gases.

Our current researches are focused on:

i. biocompatible film deposition,
ii. nanostructured films for gas and bio-sensing,
iii. new thin films for spintronics, and
iv. laser transfer of delicate complex molecules of polymers and living cells.

We supply expertise in:

a. pulsed laser deposition and reactive PLD of nanostructured films for new applications in biology, medicine, nanoelectronics, chemistry, and metallurgy,
b. controlled modifications of surfaces by laser interactions in vacuum and chemically reactive gases,
c. complex complementary investigations of thin films and multi-structures,
d. monitoring of plasmas with temporal and/or spatial resolution, and
e. theory of laser interaction with solids, gases, liquids, and plasmas.

Objectives:

1. generation of plasma under the action of pulsed high-intensity laser sources in either UV, visible or IR wavelengths range
2. investigation of laser plasmas by OES with temporal and spatial resolution. Determination of plasma parameters (electron density, temperature,...)
3. deposition of nanostructured coatings by PLA of ceramics, oxides, ferroelectrics, nitrides,...
4. spectroscopic investigation of laser induced breakdown plasmas in front of solid/liquid targets in the ambiance of various gases
5. investigation of deposited structured by complementary techniques: HREM, GIXRD, nuclear methods, ...
6. correlation of the experimental evidence obtained by plasma diagnostic with the overall characteristics of the obtained nanostructures. Improvement and optimization of deposition regimes in accordance with the best plasma spectroscopic investigations

Expected results:

1. Analysis of plasma parameters in both deposition regime and breakdown studies.
2. Correlation of measured plasma parameters with main films characteristics as thickness, uniformity, composition and morphology.
3. Development of theoretical interpretations for description of plasma initiation and evolution for nanostructured depositions.

Duration of the project: 2006 - 2008

Research teams:

Institute of Physics:

1. Prof. Dr. Nikola Konjević
2. Dr. Sonja Jovićević
3. Dr.Milivoje Ivković
4. Ivan Koralt

NILPRP:

1. Prof. Ion N. Mihailescu
2. Dr. Viorica Stancalie
3. Gabriel Socol
4. Felix Sima
5. Dr. Carmen Ristoscu

Signatures:

Institute of Physics in Zemun

General Director,

Dr.Dragan Popović

Project Coordinator,

Prof. Dr. Nikola Konjević

Date and place,

17.02.2006. Belgrade,

National Institute for Lasers, Plasma and Radiation Physics

General Director,

Dr. Eng. Rares V. Medianu

Project Coordinator,

Prof. Dr. Ion N. Mihailescu

Date and place,

Bucharest, 21.02.2006.

ПРОГРАМ НАУЧНЕ И ТЕХНОЛОШКЕ САРАДЊЕ
ИЗМЕЂУ РЕПУБЛИКЕ СРБИЈЕ И РЕПУБЛИКЕ ФРАНЦУСКЕ ЗА ПЕРИОД 2012-2013.
ПРЕДЛОГ ПРОЈЕКТА

ДАТУМ ПРИЈЕМА: Бр:

НАЗИВ ПРОЈЕКТА НА СРПСКОМ ЈЕЗИКУ	Истраживање параметара Штарковог ширења спектралних линија неопходних за анализу материала помоћу спектроскопије ласерски индукованог пробоја
НАЗИВ ПРОЈЕКТА НА ЕНГЛЕСКОМ ЈЕЗИКУ	Investigation of Stark broadening parameters of spectral lines necesarry for material analysis using laser-induced brakedown spectroscopy.

		РУКОВОДИЛАЦ ПРОЈЕКТА ИЗ СРБИЈЕ	РУКОВОДИЛАЦ ПРОЈЕКТА ИЗ ФРАНЦУСКЕ
ИМЕ И ПРЕЗИМЕ		Соња Јовићевић	Joerg Hermann
АКАДЕМСКО ЗВАЊЕ		dr	dr
Институција	Назив и адреса	Институт за физику, Универзитет у Београду Прегревица 118, Земун, 11080 Београд	LABORATOIRE LASERS, PLASMAS ET PROCEDES PHOTONIQUES (LP3) CAMPUS DE LUMINY, CASE 917 13288 Marseille http://www.lp3.univ-mrs.fr
	Тел.	+381113161258	0491829280
	Факс	*381113162190	
	E-mail	jovicevic@ipb.ac.rs	sentis@lp3.univ-mrs.fr
ДАТУМ ПОЧЕТКА ПРОЈЕКТА:			

Врста сарадње	☒ успостављање сарадње (први пут) ☐ развој раније успостављене сарадње
Постојање додатних извора финансирања за предложени пројекат	☐ Допринос установе у којој је запослен учесник ☐ Коришћење других додатних средстава (назив институције)
САДРЖАЈ ПРОЈЕКТА (кратак опис пројектних активности и очекиваних резултата, мин. 500, мах. 1500 речи)	**Обавезно попунити поље** Прва фаза у изради пројекта посвећена је дијагностици ласерски произведене плазме и њеном просторном и временском развоју. Прецизно мерење параметара Штарковог ширења захтевају познавање температуре плазме и електронске густине у функцији простора и времена. Мерења ће бити извођена на легурама, укључујући више елемената за које параметри Штарковог ширења треба да буду измерени као и макар један елемент са спектралним линијама које омогућавају мерења температуре и електронске густине. Ласерска аблација ће се изводити у аргонској атмосфери на субатмосферском притиску чиме се омогућавају плазме са жељеним варијацијама у електронској густини и темпратури. Просторна и временска спектроскопска мерења изводе се помоћу спектрометра високе резолуције. Како ласерски произведена плазма има цилиндричну симетрију, добијени просторно разложени спектри ће се обрађивати помоћу Абелове инверзије, чиме се добија права радијална расподела емисије спектралне линије. Након просторних и временских мерења еволуције електронске густине и температуре плазме, емисије спектралних линија одабраних прелаза ће бити посматране у другом делу студије. Као у претходним мерењима, спектрометар ће се користити за добијање спектралинх облика у функцији времена и простора. Абелова инверзија служиће за добијање радијалне расподеле емисије. Коначно, параметри Штарковог ширења биће утврђени за различите опсеге температуре и унесени табеларно у спектроскопску базу података која ће бити објављена у одговарајућем научном часопису. Поред тога, добијени параметари Штарковог ширења биће употребљени за побољшавање прецизности мерења у ЛИБС.
НАУЧНА БИОГРАФИЈА ИСТРАЖИВАЧКИХ ГРУПА (српског и француског тима)	**Обавезно попунити поље**

Руководилац пројекта из Србије (име и презиме, академско звање)
Др Соња Јовићевић (виши научни сарадник),

Сарадници на пројекту из Србије (име и презиме, академско звање):
Др Миливоје Ивковић (виши научни сарадник),
Марко Цвејић, (исраживач сарадник),

Руководилац пројекта из француске (име и презиме, академско звање)
Dr Joerg Hermann

Сарадници на пројекту из француске (име и презиме, академско звање):
Hammami Afef,
Ćirišan Mihaela

Proposal Submission Form

EUROPEAN COMMISSION
7th Framework Programme on Research, Technological Development and Demonstration

Coordination and support action
Support actions

A2.1: Participants

Proposal Number	000000	Proposal Acronym	BIOPOLNANOTECH	Participant Number	2

If your organisation has already registered for FP7, enter your Participant Identity Code: Not in use

Organisation Legal name	Institute of Physics
Organisation short name	IPB

Administrative Data

Legal address

Street name	Pregrevica	Number	118
Town	Beograd	Postal Code/Cedex	11080
Country	Serbia		

Internet homepage: www.phy.bg.ac.yu

Status of your Organisation

Certain types of organisations benefit from special conditions under the FP7 participation rules.

The Commission also collects data for statistical purposes.

The guidance notes will help you complete this section.

The status of the organisation is set by the proposal coordinator. If you would like to modify this information, the coordinator must modify it in the proposal set-up page

Non-profit organisation	yes
Public body	yes
Research organisation	yes
Higher or secondary education establishment	yes

Main area of activity (NACE code)

R&D on natural sciences and engineering

Proposal Submission Form

EUROPEAN COMMISSION
7th Framework Programme on Research, Technological Development and Demonstration

Coordination and support action
Support actions

A2.2: Participants

1. Is your number of employees smaller than 250? (full time equivalent)	yes
2. Is your annual turnover smaller than € 50 million?	yes
3. Is your annual balance sheet total smaller than € 43 million?	yes
4. Are you an autonomous legal entity?	yes

You are NOT an SME if your answer to question 1 is "NO"
and/or your answer to both questions 2 and 3 is "NO".
In all other cases, you might conform to the Commission's definition of an SME.
Please check the additional conditions given in the guidance notes to the forms

Following this check, do you conform to the Commission's definition of an SME: yes

Dependencies with (an)other participant(s)

Are there dependencies between your organisation and (an)other participant(s) in this proposal?

no

if Yes:

Participant Number	Organisation Short Name	Character of dependence
0	-	None
0	-	None
0	-	None

Contact Point

Person in charge (For the co-ordinator (participant number 1) this person is the one who the Commission will contact in the first instance)

Family name	Ivkovic	First name(s)	Milivoje
Title	Dr.	Sex	Male
Position in the organisation	Research Assistant Professor		
Department/Faculty/Institute/Laboratory name/...	Plasma spectroscopy and lasers laboratory		

Address (if different from the legal address)

Street name	-	Number	-
Town	-	Postal Code/Cedex	-
Country	-	Phone 1	+381113161258
Phone 2	-	Fax	-+381113162190
E-mail	ivke@phy.bg.ac.yu		

SEVENTH FRAMEWORK PROGRAMME

Proposal full title: **Functional nanostructured biopolymer coatings for controlled drug delivery and advanced biomimetic metallic implants**

Proposal acronym: **BIOPOLNANOTECH**

Type of funding scheme: **Coordination and support actions (Support)**

Work programme topics addressed: **FP7-REGPOT-2007-3**

Name of the coordinating person: **Prof. Dr. Ion Mihailescu**

List of participants:

Participant no. *	Participant organisation name	Country
1 (Coordinator)	National Institute for Lasers, Plasma and Radiation Physics (NILPRP) Laser-Surface-Plasma Interactions Laboratory	Romania
2 Partner	Institute of Physics, Beograd (IPB) Plasma Spectroscopy and Lasers laboratory,	Serbia
3 Partner	Foundation for Research and Technology-Hellas (FORTH) Institute of Electronic Structure and Laser (IESL)	Greece
4. Partner	Petru Poni Institute of Macromolecular Chemistry (PPIMC)	Romania

2.2.2. Participant 2: - **PSL - IPB (Serbia)**

The Plasma spectroscopy and Lasers (PSL) laboratory of the Institute of Physics, Belgrade (IPB) has a long tradition (more than 35 years) in producing new data for the Stark broadening of hydrogenic and non-hydrogenic lines of neutral and ionized atoms. Theirs possibilities and position in word science are the best described by the fact that they carried out in conjunction with NIST, USA [30] and nowadays independently [31,32], the critical evaluation of all available experimental data in this field. Also, they can supply new experimental and some theoretical calculations data for different elements and their ions when they are needed for diagnostics purposes. Theirs overall contribution in this field is about 100 paper in refereed journals.

The PSL IPB lab is also the most respectable one in Serbia in: OES diagnostics of different plasmas (especially laser produced one), laser applications [33], laser interaction with surfaces [34-36], LIBS [37,38], excimer laser PLD of solid samples [39] and many others. This lab also posses equipment (iCCD cameras, spectrographs, detectors, tunable lasers…), knowledge and experience for very fine temporal and spatial resolution measurements of optical signals for OES, absorption or Laser Induced Fluorescence (LIF) studies.

The staff of this lab is has also a long time experience in design and production of different plasma sources, then in gas handling, cryogenic and vacuum techniques, preparation of targets by compressing the different powders in controlled atmosphere, optics, different measurements and data acquisition techniques of weak cw or pulsed light signals and many others.

Name	Role	Contrib.	Experiance and expertise
Prof. Dr. Nikola Konjevic	Academician		Stark broadening of spectral lines, Laser physics, Optical spectroscopy
Dr Milivoje Ivkovic	PI	25% (48)	Plasma spectroscopy, Laser material processing, Laser deposition
Dr. Sonja Jovicevic	Researcher	50%	Plasma spectroscopy , LIBS, Interaction of lasers with materials
Ivan Koralt	Graduate Student	75%	Stark broadening of spectral lines
Mew hired PhD student	Graduate Student		Physical chemistry
New hired PhD student	Graduate Student		Laser deposition, Quadrupole mass spectroscopy,

[1] N.Konjević, A.Lesage, J.R.Fuhr and W.L.Wiese *J. Phys. Chem. Ref. Data* **5**, 209-57 (1976); **5**, 259-308 (1976); **13,** 619-47 (1984); **13**, 649-86 (1984); **19**, 1307-85 (1990) and **31**, 819-927 (2002),
[2] N.Konjević, *Physics Reports* **316, No.6**, 339-401 (1999).
[3] M.Ivković, S.Jovićević, N.Konjević, *Spectrochimica Acta* B **59** 591-605 (2004)
[4] M.Ivković, S.Jovićević, N.Konjević: *Applied physics in Serbia-APS,* Beograd 2002,187.
[5] S.Jovićević, N.Konjević, N.I.Chapliev, V.I.Konov and A.M.Prokhorov, *Opt.Commun.* **61**, 211-4 (1987).
[6] S. Jovićević, N.Konjević, I.Ursu, M.Ganciu-Petcu, I.N.Mihailescu, Viorica Stancalie, A.Luches, M.Martino and V.Nassisi, *Infrared Phys*. **32**, 177 (1991).
[7] V. Lazic, F. Colao, R. Fantoni, V. Spizzichino and S. Jovićević,:SAB **62,** 30-39, (2007)
[8] I. Rauschenbach, V.Lazic, S. Jovićević, E. K. Jessberger and R. Fantoni: *Lunar Planet. Sci.* **38,** 1284 (2007)
[8] M. Ivković, S. Jovićević, V. Djoković and R. Zikic, *XVI National Symposium on Condensed Matter Physics-SFKM 2004*, Sokobanja, 20- 23.9.2004,

Important Leg

CORDIS: EPSS

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General | Proposal Setup | Part A | Part B | History

Modification history

Date and time	Action / Form modified	Modified by:
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24/04/2007 17:04:02 CET	Login attempt succeed	Coordinator
24/04/2007 16:59:53 CET	Login attempt succeed	Coordinator
24/04/2007 16:59:03 CET	Document BIOPOLNANOTECH.pdf created	Coordinator
24/04/2007 16:57:19 CET	Login attempt succeed	Coordinator
24/04/2007 16:51:15 CET	Login attempt succeed	Coordinator
24/04/2007 16:46:50 CET	Login attempt succeed	Coordinator
24/04/2007 16:39:12 CET	Login attempt succeed	Coordinator
24/04/2007 16:34:02 CET	Login attempt succeed	Coordinator

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УЧЕШЋЕ НА ДОМАЋИМ ПРОЈЕКТИМА

Кандидат је од 1984 непрекидно учествовао на пројектима из области основних истраживања Министарства надлежних за науку:

1984 – 1985 Плазмена енергетика
1985 – 1990 Физика плазме и ласера
1990 – 1995 Спектроскопија плазме
1995 – 2000 Спектроскопија плазме
2000 – 2006 Плазма и пражњења: радијациона својства и интеракција са површинама
2006 – 2011 Нискотемпературна плазма и пражњења: Радијациона својства и интеракција са површинама
2011 – 2015 Спектроскопска дијагностика нискотемпературне плазме и гасних пражњења: облици спектралних линија и интеракција са површинама

Кандидат је непрекидно учествовао на пројекту ОБЛИЦИ И ПОМЕРАЈИ СПЕКТРАЛНИХ ЛИНИЈА У ГАСНОЈ ПЛАЗМИ И ГАСНИМ ЕЛЕКТРИЧНИМ ПРАЖЊЕЊИМА под руководством проф.др Николе Коњевића редовног члана САНУ и професора емеритуса Физичког факултета Универзитета у Београду. Потврда кандидатовог учешћа на овом пројекту су годишњи Билтени фонда за научна истраживања САНУ:

Билтен 30 (2004) стр. 31
Билтен 31 (2005) стр. 29
Билтен 32 (2006) стр. 32
Билтен 33 (2007) стр. 32
Билтен 34 (2008) стр. 28
Билтен 35 (2009) стр. 33
Билтен 36 (2010) стр. 36
Билтен 37 (2011) стр. 29
Билтен 38 (2012) стр. 30
Билтен 39 (2013) стр. 29
Билтен 40 (2004) стр. 37.
Ови билтени доступни су на линк-у: http://www.sanu.ac.rs/Projekti/Projekti.aspx

Кнадидат је учествовао и на пројектима примењених истраживања финансираних од стране Министарства за науку:

- Пројектовање CO_2 ласерског система за развој технологије обраде неметала – евиденциони број. Z-60118
- Затопљени угљен диоксидни ласер евиденциони број I-60091

Република Србија
МИНИСТАРСТВО ПРОСВЕТЕ И НАУКЕ
Комисија за стицање научних звања

Број:06-00-75/261
25.05.2011. године
Београд

На основу члана 22. става 2. члана 70. став 6. Закона о научноистраживачкој делатности ("Службени гласник Републике Србије", број 110/05 и 50/06 – исправка и 18/10), члана 2. става 1. и 2. тачке 1 – 4.(прилози) и члана 38. Правилника о поступку и начину вредновања и квантитативном исказивању научноистраживачких резултата истраживача ("Службени гласник Републике Србије", број 38/08) и захтева који је поднео

Институт за физику у Београду

Комисија за стицање научних звања на седници одржаној 25.05.2011. године, донела је

ОДЛУКУ
О СТИЦАЊУ НАУЧНОГ ЗВАЊА

Др Миливоје Ивковић

стиче научно звање

Виши научни сарадник

у области природно-математичких наука - физика

О Б Р А З Л О Ж Е Њ Е

Институт за физику у Београду

утврдио је предлог број 256/1 од 22.02.2011. године на седници научног већа Института и поднео захтев Комисији за стицање научних звања број 289/1 од 03.03.2011. године за доношење одлуке о испуњености услова за стицање научног звања ***Виши научни сарадник***.

Комисија за стицање научних звања је по предходно прибављеном позитивном мишљењу Матичног научног одбора за физику на седници одржаној 25.05.2011. године разматрала захтев и утврдила да именовани испуњава услове из члана 70. став 6. Закона о научноистраживачкој делатности ("Службени гласник Републике Србије", број 110/05 и 50/06 – исправка и 18/10), члана 2. става 1. и 2. тачке 1 – 4.(прилози) и члана 38. Правилника о поступку и начину вредновања и квантитативном исказивању научноистраживачких резултата истраживача ("Службени гласник Републике Србије", број 38/08) за стицање научног звања ***Виши научни сарадник***, па је одлучила као у изреци ове одлуке.

Доношењем ове одлуке именовани стиче сва права која му на основу ње по закону припадају.

Одлуку доставити подносиоцу захтева, именованом и архиви Министарства просвете и науке у Београду.

ПРЕДСЕДНИК КОМИСИЈЕ
др Станислава Стошић-Грујичић,
научни саветник

МИНИСТАР
Проф. др Жарко Обрадовић