1. SOME OF THE MAIN RESULTS OF THE OBSERVATORY'S RESEARCH ACTIVITY

The essential contributions to the science, with an echo in the international scientific community are obviously the contributions published in international journals. That is why a review of results of Belgrade Observatory's fellows just in such publications will be presented, as well as of published stellar catalogues which are commonly the results of an effort of many years and are of a particular interest to the astronomical community. The results of observational programmes, review articles in books of international standing and theses will be mentioned as well.

A very extensive list of line broadening data is of interest in analysis and modeling of stelar plasma, in stellar opacity calculations, abundance determinations, investigations of subphotospheric layers and other astrophysical problems. The interest in such data has been particularly stimulated by the developement of space astronomy where an extensive amount of spectroscopic information over large spectral regions of all kind of celestial objects has been and will be collected, stimulating the spectral–line–shape research.

In order to complete as much as possible such data needed in astrophysical and laboratory plasma research and stellar opacity calculations, Dimitrijević and Sahal-Bréchot continued in 1997 the work on their project to provide Stark broadening data for a large range of atoms and ions, and published semiclasical perturbation results for Stark widths and shifts of Ba I, Ba II and P IV.

Barium is one of thermonuclear s - processes product in stars and its overabundance is observed in CH subgiants, characterized by enhanced Sr and Ba lines, and in metal deficient barium stars, giants showing overabundance of s-processes elements. Barium lines are present in solar and stellar spectra. E.g. Ba I and Ba II lines have been observed (1993) by Komarov and Basak in the spectra of Sun and two Praesepe's stars. Barium lines are also of interest in the investigation of laboratory plasmas and Stark broadening of Ba I and Ba II lines has been considered experimentally and theoretically in a number of articles. Dimitrijević and Sahal-Bréchot (1997a) have calculated within the semiclassical-perturbation formalism electron-, proton-, and ionized helium-impact line widths and shifts for 14 Ba I and 64 Ba II multiplets, for perturber densities $10^{15} - 10^{18}$ cm^{-3} and temperatures T = 2,500 – 50,000 K for Ba I and T = 5,000 – 100,000 K for Ba II.

The obtained results are compared with the critically selected experimental results, and the existence of large differences between particular experiments and between theory and experiment has been stated. The agreement exists between widths of Dimitrijević and Sahal-Bréchot (1997a) for $6s^2S$-$6p^2P^o$ multiplet and those found by

Fleurier, Chapelle and Sahal-Bréchot (1977), that experiment having critically been estimated by Konjević, Dimitrijević and Wiese as possessing the highest accuracy among Ba II experimental data. As for the shift, the best agreement is with results of Purić and Konjević (1972) for the same multiplet. Results of Dimitrijević and Sahal-Bréchot (1997a) concerning Stark width are in agreement with the semiclassical calculations of Cooper and Oertel as well as with the semiclassical calculations, based on the theoretical approach developed by Griem, Baranger Kolb and Oertel (1962) and further improved and described in detail by Jones, Benett and Griem (1971) and Griem (1974), performed by W.W. Jones (1976), and Purić, Dimitrijević and Lakićević (1978). The obtained results relating to the shift are in agreement within the error of the method with the semiclassical calculations of W.W. Jones, but in strong desagreement with the calculations of Gorchakov and Demkin (1978), performed within the semiclassical approach of Vainshtein and Sobel'man, with the semiempirical calculations of Purić and Konjević (1972) and with the simple estimates of Lakićević (1983). New high precision measurements of Stark broadening parameters for Ba I and Ba II lines will be of interest in the development of theoretical methods treating heavy atoms and ions.

Stark broadening parameters of P IV lines are of interest not only in the plasma diagnostic but in the research of regularities and systematic trends and theoretical considerations as well. For this reason, Stark widths for P IV $4s^1S$ - $4p^1P^o$, $4s^3S$ - $4p^3P^o$ and $3p^3P^o$ - $3d^3D$ multiplets have been determined previously by Dimitrijević and Konjević in 1981, and by Dimitrijević in 1988 within the modified semiempirical approach of Dimitrijević and Konjević, Griem's semiempirical approach, Griem's symplified semiclassical approach and its modification by Dimitrijević and Konjević. Dimitrijević and Sahal-Bréchot (1997b) have calculated within the semiclassical-perturbation formalism electron-, proton-, and He III-impact line widths and shifts for 114 PIV multiplets, for perturber densities 10^{15}– 10^{20} cm^{-3} and temperatures T = 5,000 – 1,000,000 K. The obtained semiclassical Stark widths have been compared with the calculations of Dimitrijević by using the modified semiempirical approach, Griem's semiempirical approach, simplified semiclassical approach and its modification. The best agreement is with the results obtained by using the simplified semiclassical approach. For further development and rafinement of the theory, the corresponding experimental data will be of course very useful.

In 1997, Dimitrijević published the bibliography with citation index: "Spectral Line Shapes Investigations in Yugoslavia and Serbia 1993-1997" containing also a review of the results and achievments. Three previously published Bibliographies with citation index on Spectral Line Shapes Investigations in Yugoslavia, cover the period 1962 - 1993. The analysis for the 1993 - 1997 period shows that from September of 1993 up to the March of 1997, 261 articles concerning line shapes investigations have been published by Yugoslav (Serbian) authors in addition. In Serbia 2 Ph. D. and 9 M. Sc. Theses concerning this research field have been defended. Accordingly, since the first article on this topic, published in 1962, up to the March 1997, 1129 (926 by Serbian authors) bibliographic items have been published by 146 Yugoslav authors (119 from Serbia, 26 from Croatia and 1 living in France). In the considered period various problems have been investigated. Stark broadening of hydrogen and hydrogen-

like emitter lines has been studied, in particular for He II line shapes, and hydrogen line shift due to magnetization of moving plazma. Also, the attention has been paid to the study of H beta line shapes in the presence of a D.C. magnetic field, to the investigation of hydrogen line shapes in a plane - cathode abnormal glow discharge, radio - frequency discharges and other discharges, the boundary layer influence on low n Balmer lines and to the influence of ion dynamics.

Work on the experimental determination of Stark broadening parameters of non-hydrogenic atoms and ions has been continued during the considered period: Stark broadening of the following atoms and ions has been investigated: Ar I, Ar III, Cd II, Cu I, F V, Fe I, Hg I,Na I, N II, N III, N IV, Ni I, II, O III, O IV, S III, and Si I. Also, the influence of ion dynamics, temperature dependence, departure from LS coupling and Li- , Be- and B- isoelectronic sequence have been investigated.

Using the semiclassical perturbation approach, the spectra of the following elements have been investigated: Be I, Mg I, Al I, Rb I, Se I, Sr I, Ba I, Li II, Mg II, Fe II, Ni II, Ba II, B III, Be III, S III, Al III, C IV, O IV, P IV, S IV, C V, O V, P V, F VII, Ne VIII, Na IX, Al XI and Si XII. The effects of oscillator strength values on Stark broadening parameters have been investigated as well.

When it was not possible to use the semiclassical perturbation approach with the appropriate accuracy due to the lack of reliable atomic data, the modified semiempirical method of Dimitrijević and Konjević and other approximate methods have been applied. Such methods have been investigated in several papers as well as the case of the complexity of the radiator. The modified semiempirical approach has been applied to the lines of Sc II, Bi II, Cd II, I II, As II, Zn II, Br II, Sb II, Y II, Zr II, Kr II, Xe II, Zn III, Ge III, As III, Se III and Cu IV.

A special attention has been paid in a number of papers to the investigation of regularities and systematic trends of Stark broadening parameters. Similarities of Stark broadening parameters within spectral series have been investigated as well as systematic trends for the same type of transition within a homologous, isonuclear and isoelectronic sequence. By using regularities and systematic trends, Stark broadening parameters of the following emitters have been predicted: Mg I, Mg II, N V, O VI, S VI, Fe I, Fe II, Fe III, Fe IV, C IV, Si IV, Na IX - Ti XX and doubly-charged ion off-resonance .

Astronomical aspects of spectral line shapes research were studied in a number of publications, such as optical depths of the formation of Fraunhofer lines, microturbulent sensitivity of solar spectral lines, Mg II h and k lines in spectra of alpha Orionis, IM Pegasi and HR 7275, IUE spectra of mu Cephei, Fourier analysis of rotationally broadened stellar spectra, and Stark broadening parameters in Solar and stellar plasma research and in hot star spectra investigation. At Belgrade Observatory the programme of monitoring of activity - sensitive spectral lines of the Sun as a star, during a 11-years solar cycle is in the course of realization. In accordance with this programme the solar activity effect on spectral lines, as well as the effect of photospheric parameters on such spectral lines have been investigated in several papers. In view of the need to obtain a better connection between astronomical observations and theoretical interpretations of astrophysical spectra, the radiative transfer investigations have also been carried out. Moreover, the influence of the gravitational field on

the shape of spectral lines of Seyfert galaxies and quasars has also been studied. The work on the formation of a Data Base for the Active Galactic Nuclei (AGN) spectral lines is also in progress.

G. Djurašević published two papers (Djurašević 1996a, 1996b) with the results of his investigation of close binaries. The former paper (Djurašević 1996a) contains a model synthesizing the light curves of novae - like stars, as well as of active close binaries (CB) in the phase of an intensive matter exchange between the components with accretion onto a white dwarf. The model considers the radial and azimuthal temperature distributions in the disk enabling a successful interpretation of asymmetrically deformed light curves characteristics of the systems. The analysis of the observed light curves is performed by using the inverse-problem method adapted to this model. In the particular case the parameters of the dwarf-nova OY Car are estimated on the basis of the U and B observations. The synthetic light curves obtained through the inverse-problem solving, as a whole, fit the observations well which indicates that it is possible to estimate the system parameters on the basis of the model proposed here.

The obtained results indicate a complex hot-spot structure approximated in the model with two components - a central part and a surrounding spot larger in size. For the mass ratio of the components q=0.102 one finds for the orbit inclination about $83^{o}.8$. The analysis shows that the disk radius is about 0.51 of the corresponding Roche lobe radius. On the basis of U and B light curves the quiescent disk-edge temperature is estimated. Estimated have also been the disk size, its thickness and the white-dwarf radius.

The obtained results are in a relatively good agreement with the system parameters estimated earlier by Wood, Horne, Berriman and Wade. This indicates that the proposed model of the system and the corresponding inverse-problem method briefly presented here are fully applicable to the analysis of active CB light curves in this evolutionary phase. Though the model given here includes a number of approximations, it allows an independent procedure in the observational - material analysis based on the light - curve synthesis and on the application of the inverse - problem method.Results obtained by applying such an independent method can also serve as a reasonable way in testing the solutions obtained by utilising earlier approaches.

The subject of the Djurašević (1996b) paper is the problem of stellar differential rotation in close binaries of RS CV n type. The differential - rotation parameters Djurašević finds on the basis of the migration of the depression in the light curves caused by the spot effect over the orbital phase. For that purpose, a simple model of Busso, Scaltriti and Cellino, and inverse - problem procedure, based on the Marquardt algorithm, are used. To verify the obtained solutions, the SIMPLEX algorithm is applied, suitable for the nonlinear parameter optimization. This algorithm allows a correct solution of the nonlinear equation system describing the differential rotation. The procedure is applied in the determination of the parameters of differential rotation for CV Cam, VV Mon, and SS Boo binaries.

In several previous papers (see references in Mihajlov, Ignjatović, Vasiljević and Dimitrijević, 1997), chemi-recombination processes during the free electron scattering on the quasi-molecular collisional complexes $H(1s) + H^{+}$ and molecular ions H_2^{+} in the weakly bound rhovibrational states, have been introduced and investigated by Mi-

• hajlov, Dimitrijević, Ljepojević, and Djurić. It was assumed that these molecular ions are in the ground electronic state $X^2\Sigma_g^+(1s\sigma_g)$. The mentioned chemi-recombination processes are

$$H_2^+ + e \Rightarrow H^*(n) + H(1s), \tag{1a}$$

$$H(1s) + H^+ + e \Rightarrow H^*(n) + H(1s), \tag{1b}$$

where $H^*(n)$ denotes hydrogen atom in a highly excited (Rydberg) state with the principal quantum number $n \geq 4$. It has been shown that in partially ionized plasma the processes (1a) and (1b) may be significant for the $H^*(n)$ atom populations. This conclusion has been derived from the comparison of the (1a,b) processes with the electron - electron - ion recombination processes whose importance for hydrogen plasmas is well known.

In this paper the (1a,b) processes have been considered from the aspect of their influence on $H^*(n)$ atom populations of solar photosphere and lower part of chromosphere. It was pointed out that the taking into account of these processes may be particularly important when the conditions of LTE, concerning the excited atom population distribution function, are not satisfied. Such situation exists just for the above mentioned parts of the solar atmosphere (due to their small optical depth). It has been shown that for particular layers of the solar atmosphere, the chemi - recombination processes (1a,b) could be comparable or sometimes even more important than the processes of the electron - electron - ion recombination as well as with the processes of electron - ion photorecombination, which have a particularly important role in the solar atmosphere. Consequently, the (1a,b) processes must be taken into account when modelling the solar atmosphere, together with other relevant recombination processes.

The obtained results show that the (1a,b) chemi - recombination processes evidently have an important role in the large region around the temperature minimum in the Solar atmosphere, where they are comparable or dominant in relation to the other recombination processes. Within this range they may be a quite significant factor contributing to the smaller decrease from LTE. Consequently, this shows the necessity of the inclusion of the (1a,b) processes in the modelling of the weakly ionized layers in the Solar atmosphere. For Solar and stellar atmosphere models where $T_e = T_a = T$, the expressions for the (1a,b) chemi - recombination processes total rate coefficient, given in this paper, may be used. However, for atmosphere models where the equality of T_e and T_a is not assumed, the corresponding tables and the general expressions for partially ionized nonequilibrium hydrogen plasma are given by Mihajlov, Dimitrijević, Ljepojević, and Djurić in previous articles (see references in Mihajlov, Ignjatović, Vasiljević and Dimitrijević, 1997).

Mihajlov, Djurić, Dimitrijević and Ljepojević (1997) have considered the chemi-ionization processes during $He^*(n)$ and He slow collisions

$$He^*(n) + He \Longrightarrow e + He_2^+ \tag{2a}$$

$$He^*(n) + He \Longrightarrow e + \begin{cases} He^+ + He \\ He + He^+ \end{cases} \tag{2b}$$

and the inverse $He - He^+ - e$ and $He_2{}^+ - e$ recombination processes

$$He_2^+ + e \Longrightarrow He^*(n) + He \tag{3a}$$

$$He^+ + He + e \Longrightarrow He^*(n) + He \tag{3b}$$

where $He = He(1s^2)$, $He^+ = He^+(1s)$ and He_2^+ is molecular ion in the ground electronic state $^2\Sigma_u^+$. Rate coefficients of the processes (2,3) are determined within the framework of the existing semi-classical theory, based on the mechanism of resonant energy conversion within the electronic component of the observed atomic system. This theory describes ionization in the case of an atom – Rydberg atom symmetrical collisions, and recombination in the case of electron scattering on the corresponding ion – atomic complexes and molecular ions, under conditions similar to those in weakly ionized plasma. The differential and total rate coefficients for processes (2,3) are determined in the case of non-equilibrium helium plasma with atomic temperature T_a and electronic temperature T_e, within the ranges $500\text{K} \leq T_a \leq 10000\text{K}$ and $2000\text{K} \leq T_e \leq 40000\text{K}$, with the principal quantum number $3 \leq n \leq 10$. It is shown as well that the (2,3) reaction must be treated as a factor influencing simultaneously $He^*(n)$ atom populations and free electron energy distribution for weakly ionized plasmas. Consequently, with the help of the calculated differential rate coefficient, the emitted/absorbed electron energy distributions were considered. The authors have determined in this paper also the conditions under which the considered processes are important for the kinetics of weakly ionized helium plasma. The results have been given in such a form that they can be used directly when modeling weakly ionized helium plasma.

S. Jankov took part in the multi-site spectroscopic MUSICOS 1989 campaign and the obtained results are published in Hubert, A. M. ... Jankov, S., et all (1997). Reported in the paper is the detection of rapid variability in the photospheric HeI 6678 line of the Be star 48 Per (HD 25940, HR 1273), from 258 high S/N CCD spectra taken with four 1.5-2.0 meter telescopes over three consecutive nights during the MUSICOS 1989 campaign. 48 Per is known to have presented slight long-term variations in the intensity of Balmer emission lines and in the V/R ratio. It is shown that the MUSICOS 1989 observations preceded a new activity phase. Search for line-profile variations was performed with time-series analysis and with analysis of residuals. Weak blue-to-red and red-to-blue moving subfeatures with the same acceleration have been detected in the residuals. Their presence confirms that this star is seen under a moderate angle of inclination, in agreement with estimates based on fundamental stellar parameters. A frequency, associated with the moving subfeatures mentioned above, has been firmly established from time-series analysis and corresponds more closely, in the frame of non-radial pulsations, to a tesseral mode. Two other possible frequencies have been detected but need to be confirmed with new observations obtained over a longer time span. Despite additional spectra obtained at Haute Provence Observatory, it was not possible to confirm the previous value of the orbital period or the amplitude of the radial velocity curve of 48Per, and therefore it was concluded that it is premature to search for tidally-forced oscillations.

Nesme-Ribes, Meunier and Vince (1997) published the results of their investigations of Solar dynamics over cycle 19 using sunspots as traces. Namely, the angular velocities and meridional motions of cycle 19 sunspots observed at Meudon were investigated. They compared the obtained results with cycle 21 sunspot rotation properties. They found also a complex latitudinal meridional circulation pattern similar to what was observed on cycle 21 sunspots. They also corroborated the very small sunspot covariance (i.e. angular momentum transport via Reynolds stresses), which imposes a strong constraint on the source term of the differential rotation modeling.

Milani, Nobili and Knežević (1997) published an article concerning the consideration of stable chaos in the asteroid belt. The concept of chaotic dynamics has been successfully applied to the asteroids, leading to an understanding of the main features of phenomena such as the Kirkwood gaps and the depletion of the outer asteroid belt. Most asteroids are characterized by positive Lyapounov Characteristic Exponents (LCE), which means that their orbits are chaotic. Indeed, the striking fact is that for many of them the maximum LCE is very large, with a corresponding Lyapounov time shorter than 100,000 years, as reported in this work. This finding is in apparent contradiction with the overall orbital stability observed in numerical integration covering timespans orders of magnitude longer than the Lyapounov times. More importantly, it is in contradiction with the estimated astronomical age of these small planets. The phenomenon, of which other examples are already known, is referred to as stable chaos. Milani, Nobili and Knežević (1997) have studied in particular a region, that of the Veritas asteroid family, where other causes of chaotic motion are not relevant and stable chaos can be investigated as such in its various appearances. Stable chaos is found to be due to high order mean resonances with Jupiter in combination with secular perturbations on the perihelia of the asteroids. These pertubations cause a large number of critical arguments to get in and out of the resonances and can move the orbit from one high resonance to another, in a typical irregular behavior. Since chaos is driven by secular perturbations, it is no surprise that the Lyapounov times are very close to the timescales of these perturbations. The quasi integrals of motion of asteroids with very short Lyapounov times are less stable and a slow diffusion is observed in eccentricity and inclination. There is essentially no diffusion in semimajor axis, although variations are large. These asteroids can therefore be regarded as cases of stable chaos.

Knežević, Milani and Farinela (1997) published their results of the investigation of dangerous border of the 5:2 mean motion resonance. After the discovery that asteroid (2953) Vysheslavia, a Koronis family member, has a typical dynamical lifetime of the order of 10 Myr only against "falling" into the 5:2 Kirkwood gap and ending up into a hyperbolic orbit published by Milani and Farinella in 1995, Knežević, Milani and Farinela decided to repeat the same study for two other asteroids, 1991 UA_2 and 1993 FR_{58}, lying also very close to the outer edge of the same resonance. The orbital elements of these bodies were not yet accurate enough and they appealed to observers, both professional and amateur, to get more astrometric data. Eight groups in three different countries carried out observations, and as a result the Minor Planet Center could derive updated, accurate orbits for both objects. In the considered paper they report on the preliminary results of their study. Whereas the long–term behaviour of

1991 UA_2 looks fairly regular and stable, 1993 FR_{58} exhibits a typical "stable chaos" behavior; nevertheless, it does not end up into the resonance within a time span of 50 Myr. On the other hand, its fictitious clones, placed just $3-4\times10^{-3}$ AU closer to the resonance, undergo large irregular semimajor axis changes, fall into the resonance and escape on a timescale < 1 Myr.

The CCD measurements of 123 double stars with ST-6 camera attached to the Zeiss 65/1055 cm Refractor of the Belgrade Observatory, have been published by Popović and Pavlović (1997). Between October 1994 and July 1995 they took images of double and multiple stars. Images of 84 systems, i.e. 123 pairs, were obtained successfully. On the average each pair was taken 4.5 times and every image was measured by the authors.

Sadžakov, Dačić and Cvetković (1997), published an observational catalogue containing the positions of 351 stars situated in the vicinity of radio sources, worked out by differential method in the FK5 system. The (O-C) corrections to the positions of 267 fundamental stars used in the determination of the instrument parameters are also presented. The star positions are derived from observations with the Belgrade Large Meridian Circle during 1991-1993.

Two review articles (invited lectures of the 18th Int. Symp. on the Physics of ionized gases) have been published in 1997 in the book The Physics of Ionized Gases. One by Popović and Dimitrijević (1997) on the modified semiempirical theory and its application to lines from complex spectra, and the other in the same book by Mihajlov and Dimitrijević (1997), on processes involving ion atom complexes in weakly ionized labortory and astrophysical plasmas.

During 1997, two M.Sc. theses have been finished. The M.Sc. thesis of Goran Damljanović (1997) presents an analysis of the Belgrade latitudes changes for the period 1949-1985, and M.Sc thesis of Bora Jovanović concerns aproximative ephemeris in dynamical astronomy.

The "small Refractor", that is the ZEISS 20/302 cm. equatorial, has been employed in the planed observations of the radiation flux of the 31 Solar spectral line and the measurements of their equivalent widths. The instrumental profile of the spectrograph has been determined by means of a laser source. The preparations for the 1999 Solar eclipse observation have been continued.

The ASKANIA 13.5/160 cm. astrograph rendered its services in the observations of 6 comets and 3 asteroids with the aid of CCD ST-6 and ST-8 cameras. The results have been announced in several IAU Circulars.

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