1. SPECTRAL LINE SHAPES INVESTIGATION IN YUGOSLAVIA 1962–1985

As the typical information in astronomy is obtained by analyzing the radiation. The understanding of astrophysical spectral line shapes is of great importance. Spectral line shapes are an important research field, particularly in special laboratories and institutions formed in order to provide basic physical data to astronomers, as e.g. JILA (Joint Institute for Laboratory Astrophysics) in Boulder. Stark and other broadening mechanisms for lines in astrophysical spectra are also investigated within the comission 14 of the IAU for fundamental spectrosopic data.

Typical problems where spectral line shapes investigation is important, may be devided in following groups:

1) Quantitative and qualitative investigation of laboratory and astrophysical plasma spectra;

2) diagnostics of laboratory and astrophysical plasma;

3) research connected with termonuclear fusion and laser produced plasma;

4) determination of chemical abundances in stellar atmospheres using absorption line profiles;

5) investigation of recombination radio line profiles in ionized hydrogen regions as e.g. Orion nebula;

6) radiation transfer through stellar and laboratory plasmas.

Spectral line shapes enter the analysis of a stellar spectrum essentially in two ways:

a) Selected lines from which we may derrive information about stellar parameters require reliable line shape theory and data of high accuracy for the contribution of the main broadening mechanism.

b) For the bulk of ($\geqslant 10^6$) lines, as well as for smaller contributions to the main broadening mechanisms, broadening parameters of only modest accuracy are sufficient. Such lines only add together to the total absorption coefficient, which determines the atmospheric stratification, and we need only the good average accuracy while the accuracy for a particular line is not so important.

Stellar spectroscopy depends on very extensive list of elements and line transitions with their atomic and line broadening parameters. It is difficult to state in general terms which are the relevant transitions since the atmospheric composition of a star is not known a priori, and many interesting groups of stars exist with very peculiar abundances as compared to the Sun.

The interest for line broadening data is stimulated also by the development of space research. Using space spectroscopy, an extensive amount of spectroscopic information over large spectral region of all kind of celestial objects has been and will be collected, stimulating line shapes research.

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Since the first article on this topic (Vujnović et al., 1962) up to the august 1985, 371 publications concerning line shapes investigations have been published by 68 yugoslav authors. The number of published articles, authors, B.Sc., M.Sc., and Ph.D. theses are given in Table 1 for every year. One might point out that 113 articles are published in international journals during considered period. Also, 11 B.Sc., 15 M.Sc. and 9 Ph.D. theses have been done. Among the published articles 15 are in Astronomy and Astrophyisics and 1 in Astrophysical Journal.

In published papers, different problems from this research field have been considered. Stark broadening investigation of hydrogen and hydrogen—like emitter lines, has a great practical importance and the corresponding attention has been payd in Yugoslavia to this problem (1, 4, 6, 71, 73, 78, 79, 86, 98, 110, 123, 128, 129, 142, 143, 151, 152, 154, 179, 216). Yugoslav scinetists have experimentally determined Balmer line profiles (1, 4, 73, 151, 152), have studied broadening of the D_β line wings (6) as well as the neutral hydrogen and ionized hydrogen line shifts (129, 154). Particular attention has been payd to the investigation of the ion dynamic influence on the neutral hydrogen line shifts (154). Calculations of hydrogen line shapes were carried out also (143), as well as the study of back reaction influence on hydrogen line far wings (110, 123). Hydrogen spectrum near the ionization limit was investigated also (86, 142, 216).

Influence of typical colder boundary layer in T—tube, on hydrogen plasma spectral line shapes was also examined (78, 79, 98, 179). The results show that line widths are larger when the considered effect is taken into account, and that the influence of the mentioned effect increases if temperature and distance from the line center increase.

Up to date, a large experimental work on Stark broadening for nonhydrogenic emitters has been done in world and Yugoslavia, in laboratory plasmas with $N_e = 2 \times 10^{13} - 4 \times 10^{17} cm^{-3}$ and $T = 2 \times 10^3 - 6 \times 10^4 K$. In figures 1—4, the situation according to the critical analysis of experimental data (91, 92, 310, 311) is shown as well as the Yugoslav research workers contribution (papers up to the middle of 1982). In figures are marked only such nonhydrogenic atoms and ions for which reliable experimental data are given in mentioned review articles. With dots are marked elements if only measurements of non Yugoslav authors are given, and with lines if there are only contributions of Yugoslav authors. We see in the figures that Stark broadening parameters are especially known for lighter elements. One can see also that number of data decrease with the increase of ionization degree. In the time of the publication of review articles (310, 311), reliable experimental data for nonhydrogenic ions four and more times charged did not existed.

In table 2 is summarized experimental work of Yugoslav scinetists on nonhydrogenic spectral lines Stark broadening determination up to the middle of 1985. From 1962 up to the august of 1985, Stark widths of 360 lines have been measured for 38 elements of 58 different emitter species, if one takes into account different ionistaion stages also. Stark shift of 187 lines for 31 element and 33 different emitter species have been measured also and a new experimental technique for Stark shift measurement has been developed (44). Results obtained during experimental investigations of nonhydrogenic emitter Stark broadening have been reported in 98 papers.

Theoretical investigations of non hydrogenic emitter Satrk broadening were developed in several directions. In the frame of semiempirical approach, investigations of the applicability of existing theory have been done (14, 15, 27, 127, 150, 166, 167, 169) and new approaches (166, 167, 169, 199, 278, 302, 341) especially convenient for quick calculations of a large number of lines have been developed too. Particularly successful is the modified semiempirical approach (200, 305, 342). Such investigations have been done also in the frame of semiclassical approach (38, 57, 87, 88, 163, 167, 168, 233, 234, 241, 265, 268, 271, 272, 274, 277, 295, 299, 304, 306, 307, 343, 348). The theory for multiply charged ions has been improved (145, 150, 169). Stark broadening parameters for large number of lines of He I (234, 271, 272, 274, 299, 306, 307, 345, 346), Na I (343, 344), K I (347) and other elements, were calculated. The special attention has been payed to the spectral lines of heavy nonhydrogenic neutrals in plasma (232, 268, 297, 304). The work on a new quantum mechanical approach to the Stark broadening of neutral helium started also (149) and the first complete quantum mechanical (strong coupling) calculations for a nonhydrogenic neutral (196, 197) has been carried out. Research on Stark broadening of multiply charged ioons was developed especially intensively. In this research field, the most of experimental (2, 54, 55, 59, 68, 70, 80–84, 94, 102, 116, 117, 135, 158, 205, 312) and theoretical (68, 80, 102, 116, 117, 123, 135, 146, 150, 158, 163–167, 178, 194, 198, 201, 233) results published in the period considered have been obtained by Yugoslav authors. The influence of the perturber path deflection from straight line, due to the back reaction of neutral emitter (88, 89, 110, 123–126, 147, 148, 300, 301) on Stark broadening has been investigated also. Results obtained show that the influence of the effect considered, increases with the decrease of temperature and with the increase of atom polarizability. In order to take into account this effect, corresponding modifications within semiclasiscal (123, 126) and adiabatic (147) theory have been made.

In several papers were investigated non isolated helium lines with forbidden components in laser produced plasma (224, 333, 334, 335, 364, 371), influence of Debye screening (242, 308) influence of different collisional processes on line broadening (231, 267) as well as the yield of resonances (autoionization) to the Satrk Broadening (230, 266).

In large number of papers, regularities and systematic trends of Stark broadening parameters have been studied (53, 69, 104, 105, 108, 109, 113, 137, 138, 145, 153, 155, 159, 160, 165, 170–172, 175, 183–186, 193, 204, 206, 212, 215, 225, 229, 241, 243, 247, 253, 256, 264, 279, 280, 286, 289, 290, 307, 308, 312, 313, 326). Similarities of Stark broadening parameters within the same multiplet and transition array, have been examined. Also, systematic trends for the same type of transitions within a homologous and isoelectronic sequence and within a spectral series, have been studied as well as the dependence of Stark broadening parameters on ionization potential (184, 185, 186, 213, 303, 325, 339, 340), giving as the result simple formulas of astrophysical importance (339, 340, 353, 360, 361). Dependence on element ordinal number has been investigated too (183, 207, 214, 253).

During line shapes studies, attention has been payed and to purely astronomical problems. The influence of rotational motions on spectral line profiles in solar prominences and spiculas (121, 122, 141), Stark broadening of heavy solar ions (195, 226), experimentally measurable consequences of anomalous red shift on the symmetrical spectral line shape (93) and the influence of different line broadening mechanisms on solar limb effect (332, 368, 369, 370) has been studied.

Particularly often are cited and used critical reviews of experimental data for Stark brodening parameters of neutral (91, 310) and ionized (92, 311) emitters. In these reviews, available experimental data are systematized and critically evaluated, which enable their easier application in astronomy and physics research fields.

Complex experimental device with absorption cells and heat–pipe (see fig. 9), for the spectroscopic investigations in emission and absorption, has been developed in the Institute of physics of the University in Zagreb. Using this device, in a series of papers, self broadening in alkali metal vapors (64, 65, 76, 96, 97, 100, 111, 115, 131, 157, 176, 181, 182, 191, 209, 211, 218, 261) and self broadening of Tl 377,6 nm line (132, 133) has been studied. Assymetry of principal series lines of Cs (52, 60, 61, 66, 67, 99, 156) and Rb (156) was particularly investigated, far wings were studied and interaction potential and Van der Waals constant were determined using the principal series of Cs

(62, 63, 77, 130) and Rb (130). Also, peculiar wing assymetry of Li and Na (292) resonance lines has been examined.

In several papers influence on spectral line shapes of emitter (apsorber) non resonant interaction with neutral atoms has been examined. Van der Waals interaction in excited alkali dymers (356) has been studied. Wings (especially their assymetry) of Na lines broadened by collisions with Cs, Rb and K (328, 329), wings of K lines broadened by collisions with Cs (187, 188, 217) and Ar (250), interaction potential between K and Ar (235, 236, 275) and the influence of K–Rb collisions on K lines within impact approximation (260, 291, 297) have been investigated.

Interference and diffuse continua in the Rb_2 spectrum (285, 318, 354); triplet – triplet transitions in dense lithium vapors (330); triplet satellites in the spectrum of alkali homonuclear molecules (316, 367); satellites in alkali metal lines (144, 190, 221, 319); diffuse bands in absorption and emission spectra of dense Li, Li_2, Na, Na_2, K, K_2 and Rb (251, 252, 283, 284, 316, 317, 320, 321, 322, 357, 365) and also tirplet satellite bands in the wings of alkali lines (177, 189, 192, 210, 219, 262, 263, 293, 294, 331) have been studied. Finaly, influence of collisional processes on line shapes connected with redistribution and radiative transfer problem (140, 161, 180, 298) has been examined.

In order to see the contribution of Yugoslav scinetists, one might analyse also Bibliographies on atomic spectral line shapes and shifts for the period 1889–1978 (Fuhr et al. 1972, 1974, 1975, 1978 – complete references are after the introduction in Part II). Among 16 researchers with the largest number of bibliographic unities are 4 Yugoslav scinetists (see Table 3).