BALTIC ASTRONOMY Vol. 20, No. 4 (2011), ABSTRACTS

Baltic Astronomy, vol. 20, 495–502, 2011

STARK BROADENING AND WHITE DWARFS

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. White dwarf and pre-white dwarfs are the best types of stars for the application of Stark broadening research results in astrophysics, since in the atmospheres of these stars physical conditions are very favorable for this line broadening mechanism – in hot hydrogen-deficient white dwarfs and pre-white dwarfs $T_{\rm eff}$ = 75 000–180 000 K and $\log g$ = 5.5–8 [cgs]. Even for much cooler DA and DB white dwarfs with the typical effective temperatures 10 000–20 000 K, Stark broadening is usually the dominant broadening mechanism. In this review, Stark broadening in white dwarf spectra is considered, and the attention is drawn to the STARK-B database (http://stark-b.obspm.fr/), containing the parameters needed for analysis and synthesis of white dwarf spectra, as well as for the collective efforts to develop the Virtual Atomic and Molecular Data Center.

Key words: stars: white dwarfs – Stark broadening, line profiles – databases

Baltic Astronomy, vol. 20, 503–510, 2011

VAMDC AS A RESOURCE FOR ATOMIC AND MOLECULAR DATA AND THE NEW RELEASE OF VALD

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. The Virtual Atomic and Molecular Data Centre (VAMDC) is an EU-FP7 project devoted to build a common electronic infrastructure for the exchange and distribution of atomic and molecular data. Within VAMDC scientists from many different disciplines in atomic and molecular physics collaborate with users of their data and also with scientists and engineers from the information and communication technology community. In this presentation, an overview of the current status of VAMDC and its capabilities is provided. In the second part of the presentation I will focus on one of the databases which have become a part of the VAMDC platform, the Vienna Atomic Line Data Base (VALD). VALD has developed into a well-known resource of atomic data for spectroscopy, particularly in astrophysics. A new release, VALD-3, will provide numerous improvements over its predecessor. This particularly relates to the data contents where new sets of atomic data for both precision spectroscopy (i.e., with data for observed energy levels) as well as opacity calculations (i.e., with data involving predicted energy levels) have been included. Data for selected diatomic molecules have been added, and a new system for data distribution and data referencing provides more convenience in using the third release of VALD.

Key words: databases: catalogs – atomic data – molecular data

Baltic Astronomy, vol. 20, 511–515, 2011

STARK BROADENING OF CARBON AND OXYGEN LINES IN HOT DQ WHITE DWARF STARS: RECENT RESULTS AND APPLICATIONS

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. White dwarf stars are traditionally found to have surface compositions made primarily of hydrogen or helium. However, a new family has recently been uncovered, the so-called hot DQ white dwarfs, which have surface compositions dominated by carbon and oxygen with little or no trace of hydrogen and helium (Dufour et al. 2007, 2008, 2010). Deriving precise atmospheric parameters for these objects (such as the effective temperature and the surface gravity) requires detailed modeling of spectral line profiles. Stark broadening parameters are of crucial importance in that context. We present preliminary results from our new generation of model atmospheres including the latest Stark broadening calculations for C II lines and discuss the implications as well as future work that remains to be done.

Key words: stars: white dwarfs, fundamental parameters, Stark broadening

Baltic Astronomy, vol. 20, 516–522, 2011

RECENT RESULTS FOR WIDTHS OF LINES IMPORTANT IN THE SPECTRA OF COOL STARS

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. The broadening of spectral lines by neutral perturbers is an important factor in the interpretation of the observed spectra of cool stars and is often included in the analysis by using a simple van der Waals formula. Detailed calculations are carried out for selected lines and are used to examine the validity of this formula for a range of temperatures.

Key words: atomic processes – line: profiles – Sun: photosphere – stars: white dwarfs, brown dwarfs

Baltic Astronomy, vol. 20, 523–530, 2011

COMPARISONS AND COMMENTS ON ELECTRON AND ION IMPACT PROFILES OF SPECTRAL LINES

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. Stark broadening theory is currently operated for calculating widths and shifts of spectral lines that are needed for spectroscopic diagnostics and modeling in astrophysics, laboratory and technological plasmas. We have calculated a great number of data, obtained through the impact semiclassical perturbation theory: tables have been published for neutral atom and ion emitters, and typical temperatures, electron and ion densities. They are currently implemented in the STARK-B database which participates in the European effort within the Virtual Atomic and Molecular Data Centre. Despite of that, a great number of data are still missing. In the present paper, we revisit and compare a great number of the impact Stark widths and shifts by considering their semiclassical perturbation expressions. We also provide fitting formulae which are essential for the modeling codes of stellar atmospheres and envelopes.

Key words: atomic data – atomic processes – line: profiles – astronomical databases

Baltic Astronomy, vol. 20, 531–539, 2011

OPTICAL SPECTROSCOPY WITH THE TECHNOLOGY OF VIRTUAL OBSERVATORY

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. The contemporary astronomy is flooded with an exponentially growing petabyte-scaled data volumes produced by powerful ground and space-based instrumentation as well as a product of extensive computer simulations and computations of complex numerical models. The efficient organization and seamless handling of this information avalanche stored in a world-wide spread heterogeneous databases and the facilitation of extraction of new physical knowledge about the Universe is a primary goal of the rapidly evolving astronomical Virtual Observatory (VO). We give an overview of current spectroscopic capabilities of VO and identify the future requirements indispensable for detailed multi-wavelength analysis of huge amounts of spectra in a semi-automatic manner.

Key words: virtual observatories – surveys – techniques: spectroscopic – line profiles

Baltic Astronomy, vol. 20, 540–547, 2011

STOCHASTIC PROCESSES APPLIED TO LINE SHAPES

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Abstract. We present approaches using stochastic processes for the calculation of line broadening in plasmas. The derivation of model microfield methods (MMM) based on analytic formulations is recalled, as well as an approach using a simulation of the stochastic process. We discuss the possibility of an improvement of the stochastic process by comparing our first results to *ab initio* particle simulations coupled to a numerical integration of the emitters Schrödinger equation.

Key words: line shapes – Stark effect – stochastic processes

Baltic Astronomy, vol. 20, 548–551, 2011

A STATISTICAL STUDY OF THE Si IV RESONANCE LINE PARAMETERS IN 19 Be STARS

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. Using the GR model, we analyze the ultraviolet Si IV resonance lines in the spectra of 19 Be stars of different spectral subtypes, in order to detect the presence of absorption components and to analyze their characteristics. From this analysis we can calculate the values of a group of physical parameters, such as the apparent rotational and radial velocities, the random velocities of the ion thermal motions, as well as the absorbed energy and the logarithm of the column density of the independent regions of matter which produce the main and the satellite components of the studied spectral lines.

Key words: stars: Be – techniques: spectroscopic – ultraviolet: Si IV resonance lines

Baltic Astronomy, vol. 20, 552–557, 2011

AB INITIO DETERMINATION OF ATOMIC STRUCTURE AND STARK BROADENING PARAMETERS: Pb IV AND RECENT RESULTS

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Abstract. We present a review of our previous ab initio calculations of Stark broadening parameters using semi-classical perturbation method for the calculation of Stark widths and shifts, and the SUPERSTRUCURE (SST) code for the determination of atomic structure. SST code takes into account the configuration interactions and relativistic effects. New results are also presented for some spectral lines of Pb IV. Energy levels and oscillator strengths are calculated using Hartree-Fock relativistic approach, and the Stark broadening parameters are determined using a semiclassical perturbation approach.

Key words: atomic data – atomic processes – lines: formation

Baltic Astronomy, vol. 20, 558–565, 2011

ANALYSIS OF HYDROGEN CYANIDE HYPERFINE SPECTRAL COMPONENTS TOWARDS STAR FORMING CORES

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. Although hydrogen cyanide has become quite a common molecular tracing species for a variety of astrophysical sources, it, however, exhibits dramatic non-LTE behaviour in its hyperfine line structure. Individual hyperfine components can be strongly boosted or suppressed. If these so-called hyperfine line anomalies are present in the HCN rotational spectra towards low or high mass cores, this will affect the interpretation of various physical properties such as the line opacity and excitation temperature in the case of low mass objects and infall velocities in the case of their higher mass counterparts. Anomalous line ratios are present either through the relative strengths of neighboring hyperfine lines or through the varying widths of hyperfine lines belonging to a particular rotational line. This work involves the first observational investigation of these anomalies in two HCN rotational transitions, J=1→0 and J=3→2, towards both low mass starless cores and high mass protostellar objects. The degree of anomaly in these two rotational transitions is considered by computing the ratios of neighboring hyperfine lines in individual spectra. Results indicate some degree of anomaly is present in all cores considered in our survey, the most likely cause being line overlap effects among hyperfine components in higher rotational transitions.

Key words: ISM: molecules, molecular clouds – stars: formation

Baltic Astronomy, vol. 20, 566–571, 2011

THE INFLUENCE OF CHEMI-IONIZATION AND RECOMBINATION PROCESSES ON SPECTRAL LINE SHAPES IN STELLAR ATMOSPHERES

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Abstract. The chemi-ionization processes in atom – Rydberg atom collisions, as well as the corresponding chemi-recombination processes, are considered as factors of influence on the atom exited-state populations in weakly ionized layers of stellar atmospheres. The presented results are related to the photospheres of the Sun and some M red dwarfs, as well as weakly ionized layers of DB white dwarf atmospheres. It has been found that the mentioned chemi-ionization and recombination processes dominate over the concurrent electron-atom and electron-ion ionization and recombination processes in all parts of the considered stellar atmospheres. The obtained results demonstrate the fact that the considered processes must have significant influence on the optical properties of stellar atmospheres. It is shown that these processes and their importance for non-local thermodynamic equilibrium (non-LTE) modeling of the solar atmospheres should be investigated further.

Key words: stars: atomic processes

Baltic Astronomy, vol. 20, 572–575, 2011

STUDYING THE UV Mg II RESONANCE LINES IN 20 Be STARS

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. Using the GR model, we analyze the UV Mg II resonance lines in the spectra of 20 Be stars of different spectral subtypes, in order to detect the presence of satellite or discrete absorption components. The values of some physical parameters – rotational, radial and random velocities, as well as the FWHM and the absorbed energy, as a function of the effective temperature for the studied stars are determined.

Key words: stars: emission-line, Be – stars: fundamental parameters

Baltic Astronomy, vol. 20, 576–579, 2011

STARK BROADENING OF SEVERAL Ar I SPECTRAL LINES IN THE VISIBLE SPECTRUM

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. In order to complete data on Stark broadening parameters for Ar I line in the visible spectrum, we determined Stark widths and shifts due to electron, proton and ionized helium impacts for nine lines (4191.0, 4259.4, 5912.1, 6043.2, 6045.0, 6752.9, 7503.9, 7514.6, 7724.2 Å), using jK coupling and semiclassical perturbation theory. The obtained results will enter the STARK-B database, which is a part of the Virtual Atomic and Molecular Data Center.

Key words: physical data and processes: Stark broadening, line profiles, databases

Baltic Astronomy, vol. 20, 580–586, 2011

STARK BROADENING OF SEVERAL Ne II, Ne III AND O III SPECTRAL LINES FOR THE STARK-B DATABASE

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. In order to complete Stark broadening data for Ne II and O III lines, needed for analysis of stellar atmospheres, we determined the missing parameters for the broadening by collisions with protons and ionized helium for 15 Ne II and 5 O III multiplets. Also, electron, proton and ionized helium impact broadening parameters for an important Ne II multiplet in the visible part of the spectrum and for three Ne III multiplets were calculated. The obtained data will be included in the STARK-B database, which is a part of the Virtual Atomic and Molecular Data Center.

Key words: physical data and processes: Stark broadening, line profiles, databases

Baltic Astronomy, vol. 20, 587–590, 2011

CROSS SECTIONS FOR ELECTRON IMPACT EXCITATION OF O VI LINES

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. Radiative atomic data and electron impact excitation cross sections for the $2s-2p$ transitions in O VI for transitions among the fine structure levels belonging to the $1s^2nl$ $(2 \leq n \leq 5)$ configurations have been calculated. We have extended the calculations of fine structure collision strengths up to 140 Ry and have compared our results at energies below 63 Ry to the R-matrix ones.

Key words: impact excitation by electrons, cross sections, distorted wave method, plasma diagnostics, oscillator strengths

Baltic Astronomy, vol. 20, 591–595, 2011

DIAGNOSTICS OF THE SOLAR X-FLARE IMPACT ON LOWER IONOSPHERE THROUGH THE VLF-NAA SIGNAL RECORDINGS

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. An analysis of four solar flare X-ray irradiance effects on VLF signal amplitude and phase delay variations on the NAA/24.0 kHz signal trace during the period from 2005 September to 2006 December was carried out. Solar flare data were taken from the GOES12 satellite one-minute listings. For the VLF data, recordings at the Institute of Physics, Belgrade were used. It was found that solar flare events affect VLF wave propagation in the Earth-ionosphere waveguide lowering the changes of the ionosphere electron density height profiles. This follows from the variation during the solar flare events of the following propagation parameters: the sharpness of the lower edge of the ionosphere and the reflection height.

Key words: solar flares, VLF signal perturbation, Earth-ionosphere waveguide

Baltic Astronomy, vol. 20, 596–599, 2011

STATISTICAL ANALYSIS OF LANGMUIR WAVES ASSOCIATED WITH TYPE III RADIO BURSTS: I. WIND OBSERVATIONS

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. Interplanetary electron beams are unstable in the solar wind and they generate Langmuir waves at the local plasma frequency or its harmonic. Radio observations of the waves in the range 4–256 kHz, observed in 1994–2010 with the WAVES experiment onboard the WIND spacecraft, are statistically analyzed. A subset of 36 events with Langmuir waves and type III bursts occurring at the same time was selected. After removal of the background, the remaining power spectral density is modeled by the Pearson system of probability distributions (types I, IV and VI). The Stochastic Growth Theory (SGT) predicts log-normal distribution for the power spectrum density of the Langmuir waves. Our results indicate that SGT possibly requires further verification.

Key words: Sun: wind, flares, radio radiation, Langmuir waves

Baltic Astronomy, vol. 20, 600–603, 2011

STATISTICAL ANALYSIS OF LANGMUIR WAVES ASSOCIATED WITH TYPE III RADIO BURSTS: II. SIMULATION AND INTERPRETATION OF THE WAVE ENERGY DISTRIBUTIONS

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. We have modeled electrostatic Langmuir waves by an electric field, consisting of superposition of Gaussian wave packets with several probability distributions of amplitudes and with several Poisson distributions of wave packets. The outcome of the model is that the WIND satellite observations, especially in the low frequency domain (the WAVES experiment), do not allow to conclude whether the input wave amplitude distributions are closer to the log-normal than to the Pearson type I or uniform. The average number of wave packets in 1 s is found to be between 0.1 and 50. Therefore, there is a clear need to measure Langmuir wave energy distributions directly at the waveform level, not a posteriori in the spectral domain. This is planned to be implemented on the RPW (Radio and Plasma Wave Analyzer) instrument in the Solar Orbiter mission.

Key words: solar wind – physical processes: plasmas – Langmuir waves

Baltic Astronomy, vol. 20, 604–608, 2011

MODELING OF THE CONTINUOUS ABSORPTION OF ELECTROMAGNETIC RADIATION IN DENSE HYDROGEN PLASMA

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. We investigate a new modeling way for describing the continuous absorption of electromagnetic radiation in a dense partially ionized hydrogen plasma with electron densities $5\cdot10^{18}$ – $1.5\cdot10^{19}$ cm^{-3} and temperatures 16 000–25 000 K, in the wavelength range 300–500 nm. The results can be applied to the plasma of partially ionized layers of stellar atmospheres.

Key words: ISM: extinction – stars: continuous absorption

Baltic Astronomy, vol. 20, 609–612, 2011

THE INFLUENCE OF SOLAR SPECTRAL LINES ON ELECTRON CONCENTRATION IN TERRESTRIAL IONOSPHERE

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. One of the methods of detection and analysis of solar flares is observing the time variations of certain solar spectral lines. During solar flares, a raise of electron concentration occurs in Earth's ionosphere which results in amplitude and phase variations of the recorded very low frequency (VLF) waves. We compared the data obtained by the analysis of recorded VLF signals and line spectra for different solar flares. In this paper we treated the DHO VLF signal transmitted from Germany at the frequency of 23.4 kHz recorded by the AWESOME system in Belgrade (Serbia) during solar flares in the period between 10:40 UT and 13:00 UT on 2011 April 22.

Key words: solar flares, line spectra, terrestrial ionosphere

Baltic Astronomy, vol. 20, 613–617, 2011

STARK BROADENING OF In III LINES IN ASTROPHYSICAL AND LABORATORY PLASMA

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. In the deeper layers of hot stellar photospheres the Stark widths of spectral lines can be comparable and even larger than the thermal Doppler widths. Using the semiclassical perturbation method, we investigate the influence of the collisions with charged particles for the In III lines. We determine a number of Stark broadening parameters important in the atmospheres of A-type stars and white dwarfs. Also, the obtained results are compared with the available experimental data. The results will be included in the STARK-B database, the Virtual Atomic and Molecular Data Center and the Serbian Virtual Observatory.

Key words: stars: atmospheres, spectral lines, Stark broadening

Baltic Astronomy, vol. 20, 618, 2011

PLASMAS GENERATED WITH GAS MIXTURES AT THE ATMOSPHERIC PRESSURE

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. Several applications, such as metal surface nitriding, medical instrument sterilization and chemical analysis, have been developed or improved using a gas mixture as plasmogen gas. Research carried out on these subjects covers the aspect of knowing the processes that take place in plasmas which depend on the densities of the different plasma particles and their energy values. In this paper, the results obtained from the application of spectroscopic techniques for the characterization of surface wave discharges at the atmospheric pressure, generated with more than one gas type, are presented, particularly for the Ar-He, Ar-Ne and Ar-N_2 plasmas.

Key words: physical processes: plasma, surface wave discharge – techniques: spectroscopic

Baltic Astronomy, vol. 20, 619, 2011

PLASMA TECHNOLOGY AS A NEW PRESERVATION TECHNIQUE

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. The preliminary results of using the surface wave discharge at the atmospheric pressure on groups of lentils and sherry Fino wine samples are presented. In this research, the capability of active species and UV radiation from the plasma, has been assessed on preservation of food. Besides, the generation and emission of both excited molecules in a metastable state $N_2(B^3\Pi_g \rightarrow A^3\Sigma_u^+)$ and the de-excitation of species $NO(A^2\Sigma^+)$ producing UV radiation have been also studied.

Key words: surface wave discharge – plasma technology – active species – UV radiation

Baltic Astronomy, vol. 20, 620, 2011

ON THE GAS TEMPERATURE DETERMINATION FROM VAN DER WAALS BROADENING IN ARGON – NEON MICROWAVE PLASMAS

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Received: 2011 August 8; accepted: 2011 August 15

Abstract. Recently we proposed a method to determine the gas temperature using the van der Waals broadening of atomic spectral lines for atmospheric pressure Ar-He plasma. Here our investigations are continued by studying the influence of Ar*-Ne interactions in order to enlarge the applicability of the proposed method for the determination of gas temperature in argon – neon mixtures. The Ar I 425.9 nm line is found to be suitable for the gas temperature determination.

Key words: microwave discharges, gas temperature, Ar-Ne plasma, line broadening: van der Waals