AOMIC SPECTRAL LINE BROADNING AND DATABASES FOR STELLAR PLASMA RESEARCH

• MILAN S. DIMITRIJEVIĆ
Outline

1. Needs for large line broadening data set
2. Virtual Observatories and Astroinformatics
3. Databases for Spectral Line Shapes
4. Virtual Atomic and Molecular Data Center
1. NEEDS FOR LARGE STARK BROADENING DATA SET

- DEVELOPMENT OF COMPUTERS
  FOR EXAMPLE:
  PHOENIX CODE FOR MODELLING OF STELLAR ATMOSPHERES INCLUDES A PERMANENTLY GROWING DATABASE WITH ATOMIC DATA FOR MORE THAN 500 MILLIONS TRANSITIONS

- SATELLITE BORNE SPECTROSCOPY
Example of advance of satellite born spectroscopy

Part of Chi Lupi spectrum obtained with International Ultraviolet explorer (IUE) and with Godhard High Resolution Spectrograph on Hubble telescope (GHRS). One can see how lines of trace elements become more and more important.
Example of importance of Stark broadening in Ap stars

**Fig. 4.** Comparison between the observed Cr II 3403.30 line profile (dots) and synthetic calculations with the Stark parameters from present paper (full red line) and those from Kurucz (1993) (blue dashed line).

**Fig. 6.** The same as in Fig. 4 but for the Cr II 3421.20, 3422.73 lines.
INFORMATION AVALANCHE

HUGE DATA COLLECTIONS
Sloan Digital Sky Survey SDSS,
Spectra of ~ 230 million objects
Images 16 Terabytes - to download with 10Mb/s ~5 Months
Catalogues 18 Terabytes – to download ~6m
HUGE SURVAYS
8.4m LSST Telescope 30 Terabytes per night
Petabyte order data collection
2. VIRTUAL OBSERVATORIES AND ASTROINFORMATICS

Success of IUE and HST archives
Idea of Virtual Observatory end 2000
2001-2005 FP5 Project ASTROPHYSICAL VIRTUAL OBSERVATORY – AVO → EUROPEAN VIRTUAL OBSERVATORY - EURO-VO
http://www.euro-vo.org
IVOA 2002
VIRTUAL OBSERVATORY

VO: ALL ASTRONOMICAL DATABASES IN YOUR PC ➔ DEMOCRATIZATION OF SCIENCE

THIS REQUIRES THAT ALL PLAYERS SPEAK THE SAME LANGUAGE

VO STANDARDS AND PROTOCOLS DEFINED AND ADOPTED WITHIN IVOA
e-SCIENCE IN ASTRONOMY

e-Science → New way to do science – use of huge distributed data reservoirs

FOURTH PARADIGM OF SCIENCE

- observations
- theory
- experiment
e-SCIENCE IN ASTRONOMY

e-Science → New way to do science – use of huge distributed data reservoirs

FOURTH PARADIGM OF SCIENCE
- observations
- theory
- experiment
- DATA MINING – KNOWLEDGE DISCOVERY
3. DATABASES FOR SPECTRAL LINE SHAPES

1. Atomic Spectral Line Broadening Bibliographical Database – NIST
2. VALD Vienna Atomic Lines Database
3. BALSS – Bibliography on Atomic Line Shapes and Shifts
4. Griem's Tables
5. STARK-B
Welcome to NIST's bibliographic database on atomic spectral line broadening, Version 3.0. The database currently contains 6908 references, dating from 1889 through 2017 and is updated regularly.

This database contains references to publications that include numerical data, general information, comments, and reviews on atomic line broadening and shifts, and is part of the collection of the NIST Atomic Spectroscopy Data Center. This Data Center also maintains another two bibliographic databases:

- NIST Atomic Transition Probability Bibliographic Database
- NIST Atomic Energy Levels and Spectra Bibliographic Database

References to publications containing critically compiled data can be found in a separate database of NIST compilations of atomic spectroscopy data.

For help or more information, contact A. Kramida.
Search for Publications on Atomic Line Broadening and Shifts

The database presently contains 6908 references dating from 1889 to 2017. Last updated on February 14, 2017.

For help or more information, contact A. E. Kramida.

This database was funded [in part] by NIST's Standard Reference Data Program (SRDP) and by NIST's Systems Integration for Manufacturing Applications (SIMA) Program.
Welcome to VALD3

Please enter your registered email address:

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Contact form

If you would like to register as a new user, or for any other reason would like to contact one of the managers of VALD, please complete the form below.

When registering, please provide the following information:

1. The email address at which you would like to receive the results of your VALD database queries
2. Your full name and affiliation

If you intend to access VALD-EMS from different computers, send all e-mail addresses that you intend to use. Note that the address actually extracted from an e-mail to VALD is provided through the very first line of the envelope header of an e-mail.

Your email:  
Full name:  (required for registration)
Affiliation:  (required for registration)
To:  VALD Administrator
Your message:

Send message  Clear
MOLAT
Atomic and Molecular Data

Contributing Paris Observatory laboratories:
- GEPI Galaxies, Etoiles, Physique et Instrumentation
- LERMA Laboratoire d'Étude du Rayonnement et de la matière en Astrophysique
- LESIA Laboratoire d'Études Spatiales et d'instrumentation en Astrophysique
- LUTH Laboratoire Univers et Théories

Supported by the CNRS programs:
- PCMI Physique et Chimie du Milieu Interstellaire
- PNPS Programme National de Physique Stellaire
- PNST Programme National Soleil-Terre
BALSS
- Bibliography on Atomic Line Shapes and Shifts (formerly named STARK)

Griem's Tables
- Stark broadening parameters for neutrals and singly charged ions

Stark-b
- Database for "Stark" broadening of isolated lines of atoms and ions in the impact approximation

Last update: 06/10/2008
Computerized version of the Bibliography on Atomic Line Shapes and Shifts (BALSS) by J.R. Fuhr and A. Lesage. References of articles about Stark, Doppler, Van der Waals, resonance, natural and instrumental broadening and associated topics.
Select display format (Help)

- Standard
- Personal

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<th>Authors</th>
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Advanced Search on "Type" and "Class"

Your query

Submit  Reset
STARK BROADENING PARAMETERS FOR NEUTRAL AND SINGLY CHARGED IONS:
HELIUM THROUGH CALCIUM, AND CESIUM

Choose element

H  He
Li  Be
Na  Mg
K  Ca  Sc  Ti  V  Cr  Mn  Fe  Co  Ni  Cu  Zn  Ga  Ge  As  Se  Br  Kr
Rb  Sr  Y  Zr  Nb  Mo  Tc  Ru  Rh  Pd  Ag  Cd  In  Sn  Sb  Te  I  Xe
Cs  Ba  La  Hf  Ta  W  Re  Os  Ir  Pt  Au  Hg  Tl  Pb  Bi  Po  At  Rn
Fr  Ra  Ac

Ce  Pr  Nd  Pm  Sm  Eu  Gd  Tb  Dy  Ho  Er  Tm  Yb  Lu
Th  Pa  U  Np  Pu  Am  Cm  Bk  Cf  Es  Fm  Md  No  Lr

STARK-B
Database for "Stark" broadening of isolated lines of atoms and ions in the impact approximation

- **Calculated widths and shifts:** more than 150 pubs (1984-2017)

- **SCP theory updated and operated**
  by S. Sahal-Bréchot, M.S. Dimitrijević and colleagues

- STARK B is currently developed at Paris Observatory
  - *the database has been opened since September 2008:*
  - It is a part of the atomic and molecular databases of the Paris Observatory

- Link to SerVO - Serbian Virtual Observatory
  http://servo.aob.rs

- It is node of VAMDC- Virtual Atomic and Molecular Data Centre
- it follows the standards of VAMDC and Virtual Observatories
  (Europe: IVOA International Virtual Observatory Alliance)
STARK-B


STARK-B

Database for "Stark" broadening of isolated lines of atoms and ions in the impact approximation

Lorentz Profile

The STARK-B database is now fully opened though not yet complete.

Last data update: 2012-03-30
Introduction

STARK-B is a database of calculated widths and shifts of isolated lines of atoms and ions due to electron and ion collisions.

This database is devoted to modeling and spectroscopic diagnostics of stellar atmospheres and envelopes. In addition, it is also devoted to laboratory plasmas, laser equipments and technological plasmas. So, the domain of temperatures and densities covered by the tables is wide and depends on the ionization degree of the considered ion. The temperature can vary from several thousands for neutral atoms to several hundred thousands of Kelvin for highly charged ions. The electron or ion density can vary from $10^{12}$ (case of stellar atmospheres) to several $10^{19}$ cm$^{-3}$ (some white dwarfs and some laboratory plasmas).

The impact approximation and the isolated line approximation are applied, so that the line profile is Lorentzian. The basis for calculations is the computer code which evaluates electron and ion impact broadening of isolated spectral lines of neutral atoms and ions, using the semiclassical-perturbation approach developed by Sahal-Bréchet (1969ab, 1974), and supplemented in Fleurier et al. (1977), see below. This computer code has been updated by Dimitrijević and Sahal-Bréchet in their series of papers, Dimitrijević and Sahal-Bréchet (1984) and following papers. The data are derived from this series of papers and are cited in the tables. The accuracy of the data varies from about 15-20 percent to 35 percent, depending on the degree of excitation of the upper level, and on the quality of the used atomic structure entering the calculation of scattering S-matrix leading to the widths and shifts. The more the upper level is excited, the more the accuracy is good. In the earlier papers, the used atomic structure was the so-called "Baranger and Daugaard" one (Coulomb wavefunctions + quantum defect). More recent atomic structure data are introduced in the latest papers. For more details, the reader is invited to refer to the papers cited in the tables for the used atomic data and atomic levels.

The impact approximation

The impact approximation is valid when the mean duration $\tau$ of a collision is much smaller than the mean interval $\Delta T$ between two collisions (Baranger 1958 abc). $\Delta T$ is of the order of the inverse of the collisional line width $\gamma$ expressed in angular frequency units. $\tau$ can be written as:

$$\tau = \frac{\langle p \rangle}{\langle v \rangle}$$

where $\langle p \rangle$ is a typical impact parameter and $\langle v \rangle$ the mean velocity of the collider.
Periodic table of elements

Click on a yellow case corresponding to the chosen element and then on an ionization degree. There are no data on the non-coloured cases. Then a new page appears, requiring your detailed choice.

Line widths and shifts table

Column 1
Perturber density $N$ in cm$^{-3}$

Column 2
Lower level or lower term

Column 3
Upper level or upper term

Comments to columns 2 and 3
When the fine structure splitting is small, namely if the difference between energy levels of the same multiplet is small compared to the distance to the next level linked by an allowed transition, all the fine structure lines of the same multiplet have the same width and shift. In that case the data are given for the multiplet only and for an average wavelength for the whole multiplet. If needed, the width value for a particular line within a multiplet can be obtained from:

$$W_{line} = W_{mult} l_{2line} / \lambda^2_{mult}$$

Idem for the shift

Column 4
### Ionization Degree of the Element

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- $\text{Si VI}$
- $\text{Si XI}$
- $\text{Si XII}$
- $\text{Si XIII}$
**Access to the data**

Si IV, electron Hydrogen II Helium II, me

1.00e+17

or enter a value: [ ] OK

All

or a wavelength interval

min (Å): [ ] max (Å): [ ] OK

All

**Citation**

When using these data, please refer to the original papers and to this database as:

Sahal-Bréchot, S., Dimitrijević, M.S., Moreau N., 2018. STARK-B database, [online].


**References**

- Dimitrijević M.S., Sahal-Bréchot S., Bommier Y.
References

- Dimitrijević M.S., Sahai-Bréchot S., Bommier V.
  ADS link: http://cdsads.u-strasbg.fr/abs/1991A%26AS...89..591D

- Dimitrijević M.S., Sahai-Bréchot S., Bommier V.
  ADS link: http://cdsads.u-strasbg.fr/abs/1991BOBep144...81D

Line widths and shifts (hide table)

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<th>UPPER LEVEL</th>
<th>MULTIPLET</th>
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References

- Dimitrijević M.S., Sahal-Bréchot S., Bommier V.
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- Dimitrijević M.S., Sahal-Bréchot S., Bommier V.
  ADS link: http://cdsads.u-strasbg.fr/abs/1991BOBao.144...81D

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**Fitting coefficients (hide table)**

- Export as Text
- Export as VOTable

**How to use**

Below are the equations used to get the fitted data:

- \( \log(w) = a_0 + a_1 \log(T) + a_2 (\log(T))^2 \)

- \( d/w = b_0 + b_1 \log(T) + b_2 (\log(T))^2 \)

**N.B.:** This fitting must only be used inside a temperature interval where widths and/or shifts are provided.


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For further enquiries or user support, contact:

- Sylvie Sahal-Bréchot, Observatoire de Paris, LERMA, Meudon, France
- Milan S. Dimitrijevic, Astronomical observatory, Beograd, Serbia
- Nabil Ben Nessib, King Saud University, Riyadh, Saudi Arabia
- Nicolas Moreau, Observatoire de Paris, LERMA, Meudon, France
Diagnostics and Modelling in Astrophysics: Understanding of the evolution of stars

- Thanks to considerable developments of
  - Ground based and space-born missions
  - Increased sensitivity (S/N) and spectral resolution
  - Powerful computers

Stellar interiors studies and Asterosimology
- opacities: a great number of lines of highly ionized elements are required

Nuclear processes:
- formation of elements, chemical enrichment

Interpretation of the faint observed spectrum:
faint objects (white dwarfs), faint lines (trace elements)
- Line intensities + line profiles
- Continuum
- Spectroscopic diagnostics:
  + Temperatures
  + pressure
Diagnostics and Modelling in Laboratory and Technological plasmas

- **Magnetic confinement fusion: moderately dense and hot plasmas**
- **Inertial confinement fusion (laser fusion, ion-beam fusion): dense and very hot plasmas**
- **Low temperatures plasmas**
- **Lighting discharges**

**Analysis and interpretation of the spectrum in fusion devices**
- Light elements in the divertor and edge plasma regions
- Importance of Tin, Tungsten and impurities

**Progress in low-energy light sources**
- Discharge lamps and lighting: optimisation of performances
- Rare earth elements Dy, Ho, Ce: excellent radiation sources
- **HID (High Intensity Discharge):** MH (Metal Halide) lamps, e.g. DyI3, InI, ZnI3
STARK-B: Next steps

- Insertion of MSE data (in progress)
- Insertion of little “applets” on line for users:
  - extrapolation or interpolation
    - along principal quantum numbers,
    - charge of the radiating ions (isoelectronic sequences),
    - charge of the ion collider
    - homologous ions,
- Future:
  - SCP code on line: STARK-C project
  - Insertion of quantum data in intermediate coupling: SST + DW, AS especially adapted to highly charged ions and resonance lines (Sahal-Bréchot with Elabidi & Ben Nessib (2004 and after, also with Dubau and Cornille 2007 and after)
SERBIAN VIRTUAL OBSERVATORY

Funded by Ministry of Education and Science through grants:
- TR13022/2008 "Serbian Virtual Observatory"
- 364402/2011 "Astroinformatics: Application of IT in Astronomy and Close Fields"

VISIT:
- Archive of photo plates taken at Astronomical Observatory in Belgrade 1934–1996
- EuroVO for latest in the European Virtual Observatory
- IVOA for info about International Virtual Observatory Association

NEWS:
- MC and WG Meetings of COST Action 1403 "Big data in sky and Earth Observations" will be held in Belgrade March 30–31
- Mold – VAMDC node In association with Institute of Physics, a new VAMDC node is established for molecular photodissociation data
- EMOL / BEAMDB – VAMDC node for atomic collisions. In association with LaCP @ Institute of Physics
- AGN workshop in Koncharevo 7–11 October 2014
- Try our new service for fitting Fell template in AGN's.

Maintained by Darko Jevremović. Questions or Comments? Click here to send an email.
Belgrade electron/atom(molecule) database (BEAMDB)

Laboratory for Atomic Collision Processes :: Institute of Physics Belgrade

Collision Type: _______
Species: _______
Species State (product): _______
Cross Section Type: _______

Search
Photodissociation - MolD database
Institute of Physics Belgrade :: Astronomical Observatory Belgrade

individual cross sections  average thermal cross sections  plot

Molecule:  
QNJ:  
QNv:  
Search

If you find this service (data) useful, please cite the following paper
Vujić, V.; Jevremović, D.; Mihajlov, A. A.; Ignjatović, Lj. M.; Srečko, V. A.; Dimitrijević, M. S.; Malović, M.
MOL-D: A Collisional Database and Web Service within the Virtual Atomic and Molecular Data Center
Journal of Astrophysics and Astronomy, 2015, Volume 36, Issue 4, pp.693-703
Fe II template - Mozilla Firefox

Fe II (4000-5500 Å) template in AGN spectra

Fit one spectrum  Fit multiple spectra

spectrum (plain/text):  Browse...  No file selected.

Temperature (K):
Doppler width of Fe II lines (km/s):
The shift of Fe II lines (km/s):
Intensity of F Fe II group of lines:
Intensity of S Fe II group of lines:
Intensity of G Fe II group of lines:
Intensity of P Fe II group of lines:
Intensity of I Zw I Fe II group of lines:
Number of iterations:

Submit Query

Instructions:

Upload the AGN spectrum within 4000-5500 Å range, with subtracted continuum. Make spectrum to be two column ascii file (wavelength, flux) of "plain/text" mime type, regardless of extension. Put initial parameters in the form. For approximate temperature, width and shift
Instructions:
Upload the AGN spectrum within 4000-5500 Å range, with subtracted continuum. Make spectrum to be two column ascii file (wavelength, flux) of "plain/text" mime type, regardless of extension. Put initial parameters in the form. For approximate temperature, width and shift you may use the values given in the Test (down), but for intensities put the values which are approximately the same order of magnitude as the flux in your spectrum. Put 3000 iterations to obtain the best fit.

Test
For testing the program use this spectrum file data_test.txt, and put parameters of fit to be, i.e.: 10000, 1500, 0, 4, 3, 3, 3, 1 (with following order). Try application with 0 iterations, and then with 3000 iterations.

Fit one spectrum: explanation of template parameters and fitting procedure

Acknowledgments
If you find this service useful, please cite the following papers:


VAMDC

Virtual Atomic and Molecular Data Centre
VAMDC Idea

Problems in A&M data community
- LACK OF STANDARDS AND COMMON GUIDELINES
- INTEROPERABILITY problem – prevents productive search and data mining
- DATA EXCHANGE problem – informal, e-mails, ASCII files…
- OVERLAPPING OF EFFORTS
VAMDC IDEA

-Majority of developers are Astronomers, Physicists, Chemists – NEED OF HIRING COMPUTER ENGINEERS

-DATA IDENTIFICATION PROBLEM -XML schemata keys not only for data exchange but also for data identification
Virtual Atomic and Molecular Data Center (VAMDC) started 2009 as an European FP7 project with aims -To build a secure, flexible and interoperable e-science environment based interface to the existing Atomic and Molecular databases
- To work on definition of standards, testing of services
- To coordinate groups involved in the generation, evaluation, and use of atomic and molecular data.
- To provide a forum for training of potential users.
Use of A&M data and VAMDC idea
Participating Institutions. Now 33 databases involved
Astronomy
Plasma science
Atmospheric Science
Technological plasmas
Fusion community
Radiation science
Lightning industry
THANK YOU FOR ATTENTION