# *LXCat : a web-based, community-wide project on data needed in modeling low temperature plasmas*

***LXCat = ELECtron (and ion) SCATtering***

www.lxcat.net

*Presented by Leanne Pitchford, on behalf of the LXCat team*
*LAPLACE, Univ Toulouse and CNRS*
*Toulouse, France*

# Data needs in the field of low temperature plasma science (LTPS) are extensive

Electron-neutral (cross sections and/or transport coefs)

Ion-neutral (cross sections and/or transport coefs)

Neutral and ion chemistry

Plasma surface interactions

Radiation

….

***Present focus of the LXCat project (electron component):***
scattering cross sections from ground state targets, over an energy range from thermal to some kV.

# The starting point for the LXCat project (2008)

Some on-line compilations of data were available in various formats, more or less complete, accurate – examples : Phelps, Morgan, SIGLO

Extensive cross section data sets were available, hard-wired in Fortran codes – example : SF Biagi's Magbotz code (35000 lines of Fortran code) contains data for over 40 target species.

Compilations of cross section data have been published – examples : Itikawa, Hayashi,..

People are generally willing to share data.

Many data are available for cross sections for particular processes, transport coefficients in particular gas mixtures….mainly in figure format.

- The DOE report of the workshop on *Low Temperature Plasmas* (March 2008) stated as a priority to

*"Establish a clearinghouse for fundamental data for LTPS. A hierarchical evaluation, ranging from rough approximations to accurate and complete datasets, should be created. The data should be brought together, evaluated by experts, and made widely available by using up-to-date Web-based techniques."*

- Independently of this assessment, the group in Toulouse (mainly Sergey Pancheshnyi) developed an open access website, into which data can be uploaded. On-line tools were developed for manipulating data.

➔ **LXCat**

# Conclusions from the public discussion at GEC 2010

- there is considerable interest/need in the GEC community for developing modern databases and on-line tools for LTPST

- a community-wide effort is desirable with a well-identified structure to assure survivability (continuity + good technical solutions to avoid dead-ends)

- a number of people are ready to support this effort

- many questions need to be addressed ..scope, evaluation, organization, IP,.., overlap with other projects,…

- the Toulouse platform is a good starting point

➔ **GEC Plasma Data Exchange Project**

The Gaseous Electronics Conference agreed to host three workshops focusing on data for modeling LTP's.

2011 : organization of a workshop at the GEC, poster contributions on noble gases

2012 : organization of a workshop at the GEC, poster contributions on simple molecular gases

2013: organization of a workshop at the GEC, poster contributions on H2O

Most of the data presented in the workshops are now available on LXCat and intercomparisons have been presented in poster sessions at previous GEC's.

# LXCat in 2014

www.lxcat.net

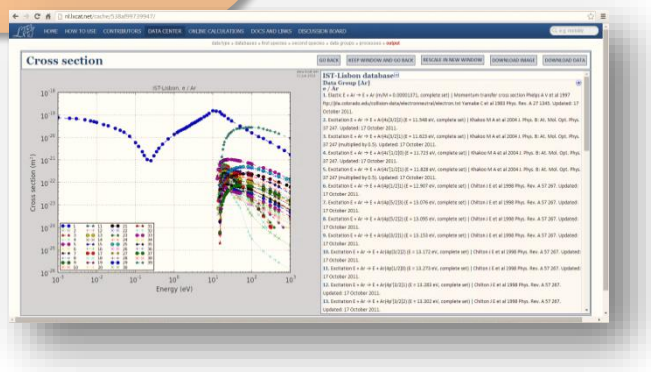
Contributors

Individual databases
~20 at present
(~ 30 people from 12 countries)

On-line tools

Users

- BSR (QUANTUM-MECHANICAL CALCULATIONS BY O. ZATSARINNY AND K. BARTSCHAT)
- BIAGI-V7.1 (MAGBOLTZ VERSION 7.1)
- BIAGI-V8.9 (MAGBOLTZ VERSION 8.9)
- BORDAGE DATABASE
- BRAY DATABASE
- DUTTON DATABASE
- FLINDERS DATABASE
- HAYASHI DATABASE
- IST-LISBON DATABASE
- ITIKAWA DATABASE
- LAPLACE (MEASUREMENTS AFTER 1975)
- MORGAN (KINEMA RESEARCH & SOFTWARE)
- NGFSRDW DATABASE
- PHELPS DATABASE
- PUECH DATABASE
- QUANTEMOL DATABASE
- SIGLO DATABASE
- TRINITI DATABASE
- URQUIJO (DE URQUIJO DATABASE, UNAM)
- VIEHLAND DATABASE
- UBC DATABASE
- BOLSIG+ SOLVER




S. Pancheshnyi *et al.*, *Chem. Phys.* **398**, 148 (2012)

# Contributors to The LXCat project

(updated November 2014)

***Website conception and development:*** S Pancheshnyi, France /Switzerland

***Electrons: Compilations of cross section data :*** MC Bordage, V. Puech, LC Pitchford, France; SF Biagi, UK; WL Morgan, AV Phelps USA; LL Alves and CM Ferreira, Portugal; Kochetov and Napartovich, Russia; Y. Itikawa, (M Hayashi), Japan; L Campbell and M Brunger, Australia + Chris Brion's library of optical oscillator strengths, Canada

***Quantum calculations:*** J. Tennyson and D. Brown, UK; O. Zatsarinny and K. Bartschat USA; I. Bray and D. Furst, Australia; Al Stauffer, Canada

***Compilations of experimental transport coefficients:*** transcription of data from publications S. Chowdhury, France/India; J. de Urquijo, Mexico; LL Alves, Portugal

***Ions:*** L Viehland, AV Phelps, USA; J. de Urquijo, Mexico

***On-line Boltzmann solver for electrons:*** GJM Hagelaar, France

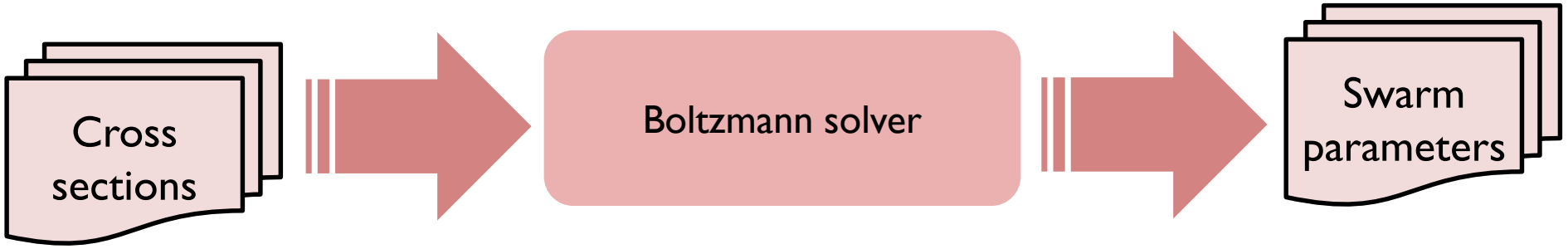
***Technical assistance:*** S. Chowdhury and B Chaudhury, France/India;

***Mirror site :*** J van Dyke, the Netherlands

# Data needs depend on the model formulation

For the electron component, the emphasis in LXCat is on the cross section data, from which swarm parameters can be derived.

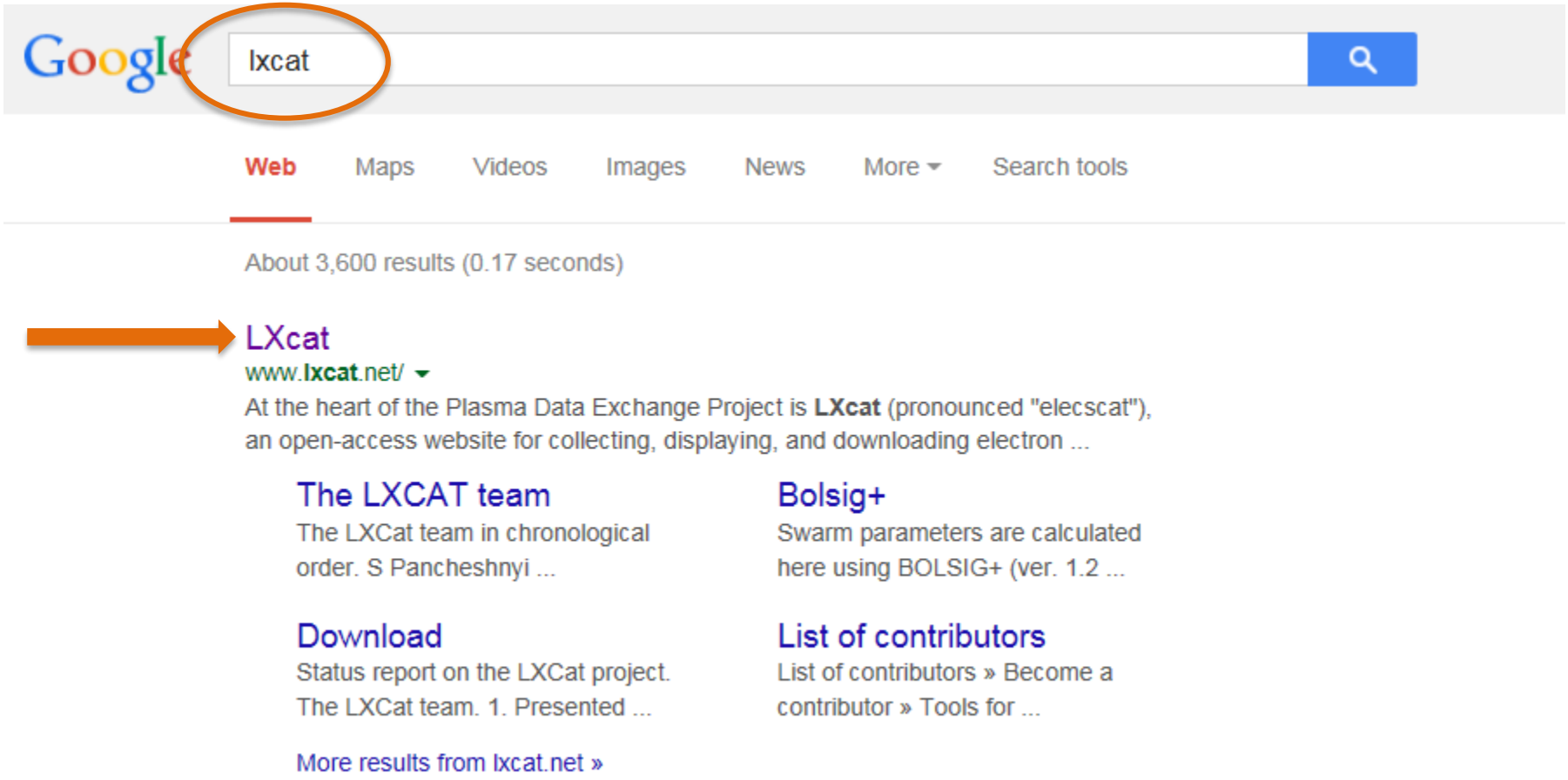
**Complete sets of cross sections:** electron-neutral (ground state) describing momentum-loss, energy-loss processes, and electron number changing processes (ionization, attachment, …)




**Swarm parameters:** electron transport (mobiity, diffusion), rate coefficients as functions of E/N (if non-Maxwellian) or average energy

Consistency of measured and calculated swarm parameters is a minimum requirement for validation of the cross section data set.

# How to find LXCat



# About the project

The **Plasma Data Exchange Project** is a community-based project which was initiated as a result of a public discussion held at the 2010 Gaseous Electronics Conference (GEC), a leading international meeting for the **Low-Temperature Plasma** community. This project aims to address, at least in part, the well-recognized needs for the community to organize the means of collecting, evaluating and sharing data both for modeling and for interpretation of experiments.
At the heart of the Plasma Data Exchange Project is **LXcat** (pronounced "elecscat"), an open-access website for collecting, displaying, and downloading electron and ion scattering cross sections, swarm parameters (*mobility, diffusion coefficient, etc.*), reaction rates, energy distribution functions, etc. and other data required for modeling low temperature plasmas. The available data bases have been contributed by members of the community and are indicated by the contributor's chosen title.

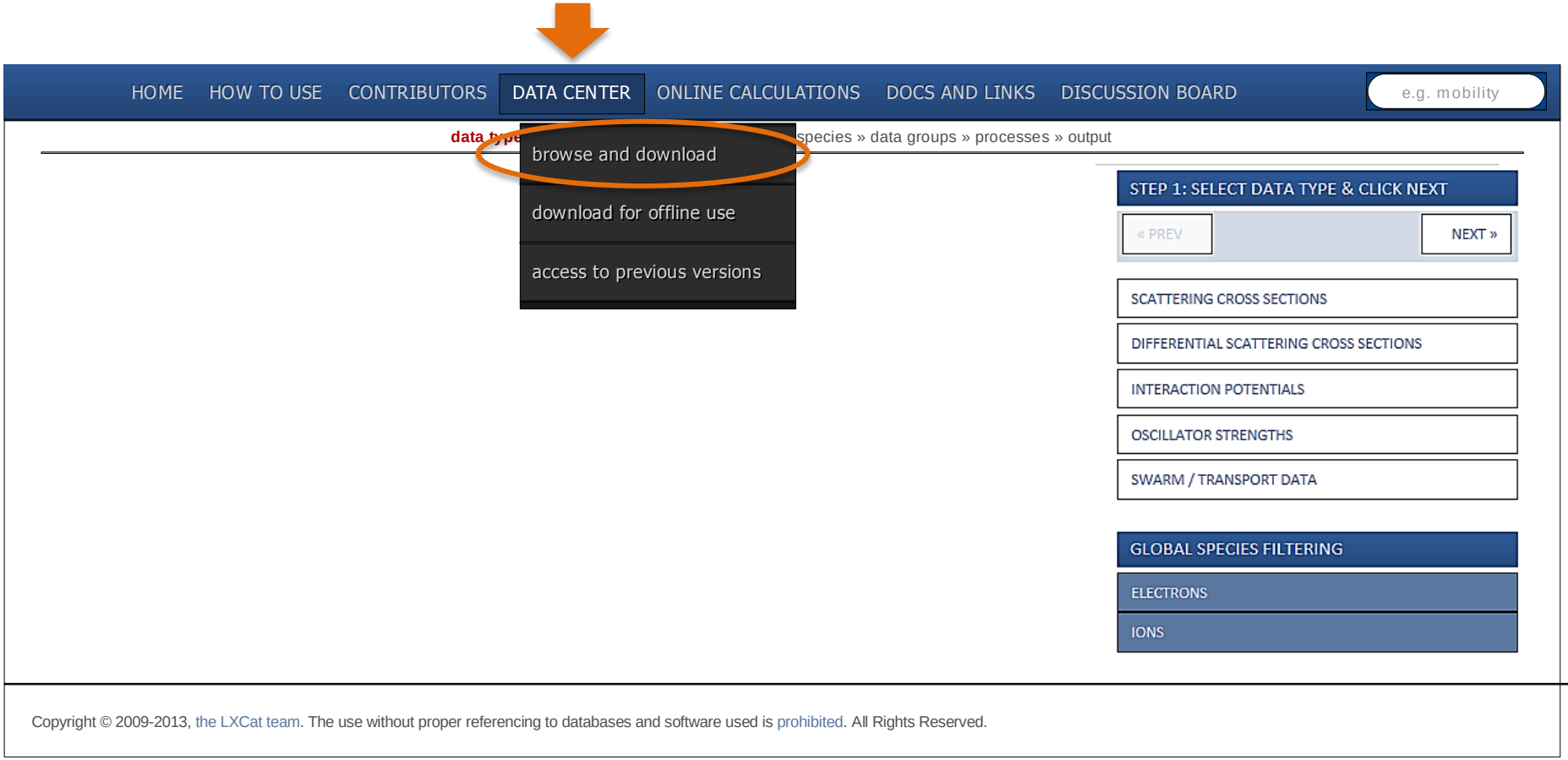
> This is a dynamic website, evolving as contributors add or upgrade data. Check back again frequently.

## Supporting organizations



PROJECT STATISTICS

**Scattering cross sections:** 19 databases | 4 x 162 species | 3.2k records | updated: 3 October 2014
**Differential scattering cross sections:** 1 database | 1 species | 31 records | updated: 7 November 2013
**Interaction potentials:** 1 database | 56 x 8 species | 567 records | updated: 23 September 2014
**Oscillator strengths:** 1 database | 65 species | 150 records | updated: 25 November 2013
**Swarm / transport data:** 8 databases | 264 x 60 species | 129.8k records | updated: 23 September 2014
**Publications, notes and reports:** 3 databases | 23 records | updated: 25 August 2013



19 databases | 4 x 162 species | 3.2k records | updated: 25 August 2014

## Databases containing complete sets of cross sections for electron scattering from ground state neutral atoms and molecules.

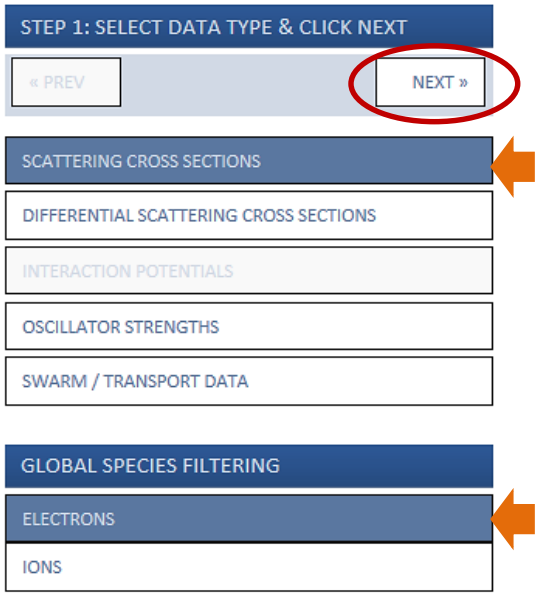
The energy range of interest is from 0 to some 100's of eV and higher. A complete set of cross sections consists of elastic momentum transfer, and total cross sections for the processes of ionization, attachment and excitation. Complete sets of cross sections are needed as input to a Boltzmann equation solver to determine the electron or ion energy distribution function.

## Databases containing partial sets of electron-neutral scattering cross sections.

Partial sets of electron neutral scattering cross sections are also included on this site. These include additional data concerning electron collisions with ground state molecules - such as total scattering, total elastic scattering - not used in the Boltzmann calculations. These also include cross sections for electron impact ionization of metastable or radicals, needed for the calculation of stepwise ionization, for example.

## Databases containing ion-neutral scattering cross sections.

The limited ion-neutral cross section data available on this site were derived assuming that the differential scattering can be reasonably well approximated as the sum of an isotropic part and a backscatter part. These two components are provided as functions of the center or mass energy.



## SIGLO database

**DESCRIPTION**: The SIGLO database is the "in-house" data used by the group GREPHE at LAPLACE in Toulouse. The data are taken from different sources as indicated for each gas. Please refer to original sources in publications. An early version of this data file, "siglo.sec", was distributed with BOLSIG. The main changes in the present version are :

The format has been changed to be compatible with BOLSIG+.

Scale factors have been incorporated in the data and no longer appear explicitly.

He : The present data are from the compilation of A.V. Phelps (see reference in the Phelps data base).

O2 : We recommend using the data in the Phelps database for this species.

H2 : We recommend using the data in the Phelps database for this species.

Cl2 : The present data are an updated compilation (Jan 2012) by J Gregorio and LC Pitchford.

Cu : Feb 2012. Digitized from Tkachev A N, Fedenev A A and Yakovlenko S I, Laser Phys. vol.17, p. 775 (2007)

Kr : Nov 2012. We re-digitized the data from figs. 1 and 5 in H. Date, Y. Sakai and H. Tagashira, J. Phys. D 22 1478 (1989). With respect to the previous data from this same reference in the SIGLO database, there are some changes in the threshold values and in the magnitudes of the inelastic cross sections.

**CONTACT**: LC Pitchford and JP Boeuf

pitchford@@laplace.univ-tlse.fr and jpb@@laplace.univ-tlse.fr

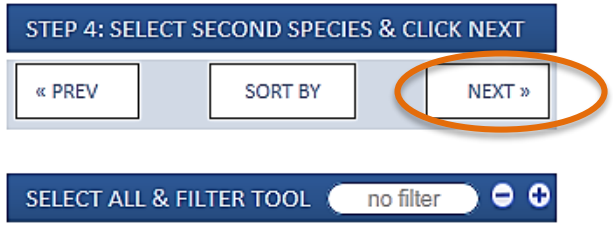
**SCATTERING CROSS SECTIONS**

STEP 2: SELECT DATABASES & CLICK NEXT

« PREV SORT BY NEXT »

SELECT ALL & FILTER TOOL no filter

- Morgan (Kinema Research & Software)
- SIGLO database
- Phelps database
- Biagi-v8.9 (Magboltz version 8.9)
- Hayashi database
- IST-Lisbon database
- Itikawa database
- BSR (Quantum-mechanical calculations by O. Zatsarinny and K. Bartschat)
- Biagi-v7.1 (Magboltz version 7.1)
- Puech database
- QUANTEMOL database
- TRINITI database
- Bordage database
- NGFSRDW database
- Bray database
- FLINDERS database




## Ground states

Ar | BF3 | C | C2 | C2H2 | C2H4 | C2H6 | C2OH6 | C3 | C3H4 | C3H6 | C3H8 | C3N | CCl2F2 | CCl4 | CF | CF2 | CF4 | CH | CH2 | CH3 | CH4 | CHF3 | CNH | CO | CO2 | CONH3 | COS | CS | CaF

Cl2 | Cu | D2 | F2 | F2O | H | H2 | H2O | H2S | H4C | HBr | HCHO | HCN | HCP | HCl | He | Hg | Kr | Mg | N | N2 | N2O | NH3 | NO | NO2 | Na | Ne | O | O2 | O3 | $O^-$ | PH3 | SF6 | SO2 | Si2H6

Si(CH3)4 | SiF2 | SiH4 | SiO | Xe

## State-specific and gas mixtures

Ar 3p5 4p J = 0 2p5 | Ar 3p5 4p J = 1 2p2 | Ar 3p5 4p J = 1 2p4 | Ar 3p5 4p J = 1 2p7 | Ar 3p5 4p J = 1 2p10 | Ar 3p5 4p J = 2 2p3 | Ar 3p5 4p J = 2 2p6 | Ar 3p5 4p J = 2 2p8

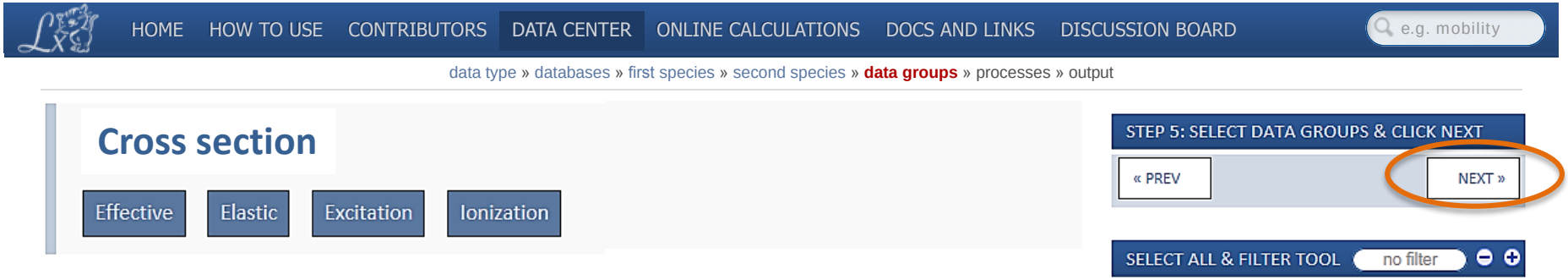
Ar 3p5 4p J = 3 2p9 | Ar 3p5 4s J = 0 1s3 | Ar 3p5 4s J = 1 1s4 | Ar 3p5 4s J = 2 1s5 | Ar 3p5 4s j = 1 1s2 | Ar 3p6 J = 0 | C2H2+ | CH+ | CO2+ | CaF+ | H(1S) | H2 (J=0) | H2 (J=1)

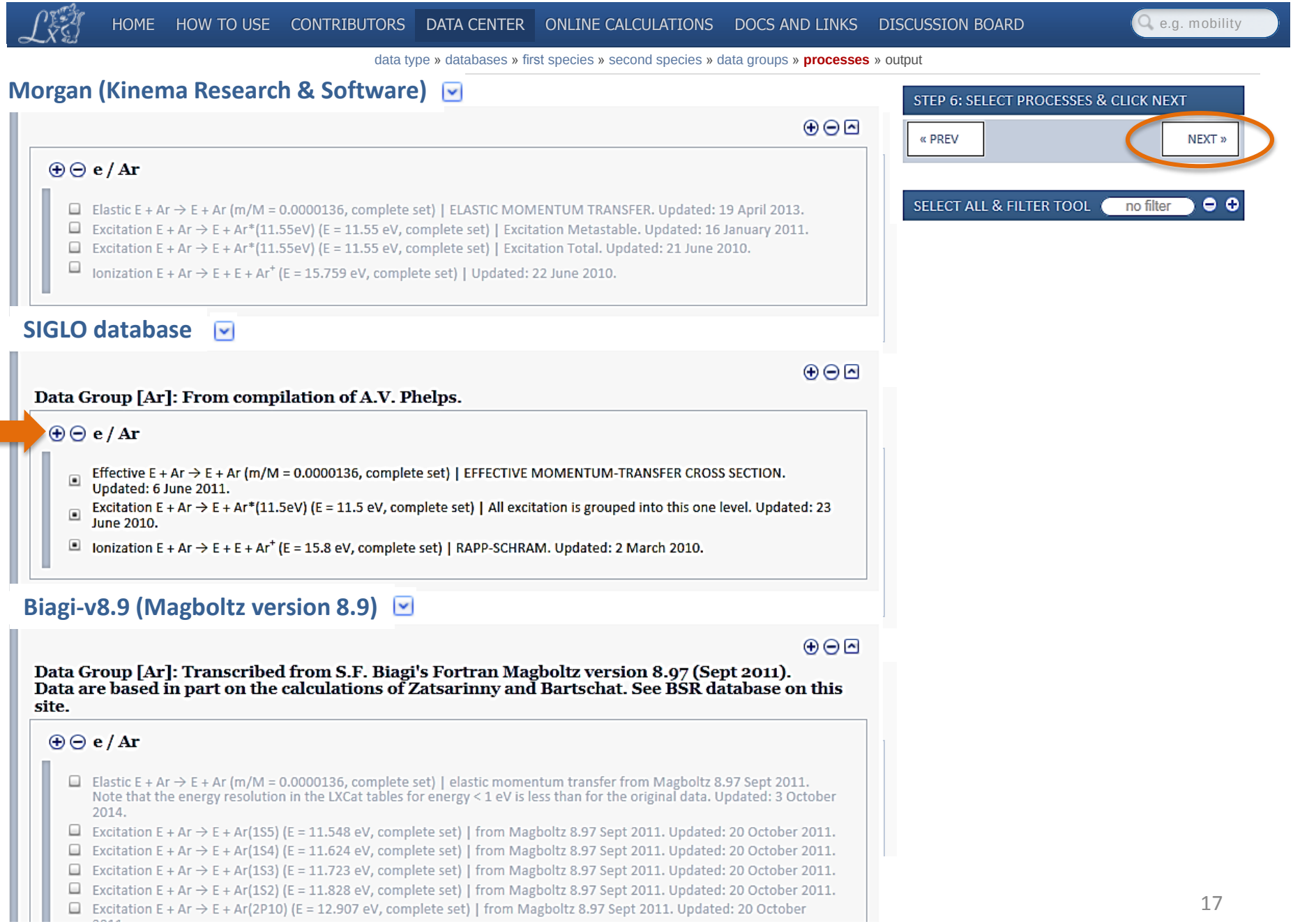
H2 (J=2) | H2 (J=3) | H2+ | H(2P) | H(2S) | H2(p) | H2(s) | H(3D) | H(3P) | H(3S) | H(4D) | H(4F) | H(4P) | H(4S) | He(s1S) | N2 (J=0) | N2 (J=1) | N2 (J=10) | N2 (J=11) | N2 (J=12) | N2 (J=13)

N2 (J=14) | N2 (J=15) | N2 (J=16) | N2 (J=17) | N2 (J=18) | N2 (J=19) | N2 (J=2) | N2 (J=20) | N2 (J=21) | N2 (J=22) | N2 (J=23) | N2 (J=24) | N2 (J=25) | N2 (J=26) | N2 (J=27) | N2 (J=28)

N2 (J=29) | N2 (J=3) | N2 (J=30) | N2 (J=4) | N2 (J=5) | N2 (J=6) | N2 (J=7) | N2 (J=8) | N2 (J=9) | N2(a) | Ne(3P2) | O2 (J=1) | O2 (J=11) | O2 (J=13) | O2 (J=15) | O2 (J=17) | O2 (J=19)

O2 (J=21) | O2 (J=23) | O2 (J=25) | O2 (J=27) | O2 (J=29) | O2 (J=3) | O2 (J=5) | O2 (J=7) | O2 (J=9) | O2(0.98) | O2(1.63) | O2(B1S) | O2(VSUM) | O2(a1D) | Xe(1s5)

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Morgan (Kinema Research & Software)
e / Ar
Elastic E + Ar → E + Ar (m/M = 0.0000136, complete set) | ELASTIC MOMENTUM TRANSFER. Updated: 19 April 2013.
Excitation E + Ar → E + Ar*(11.55eV) (E = 11.55 eV, complete set) | Excitation Metastable. Updated: 16 January 2011.
Excitation E + Ar → E + Ar*(11.55eV) (E = 11.55 eV, complete set) | Excitation Total. Updated: 21 June 2010.
Ionization E + Ar → E + E + Ar+ (E = 15.759 eV, complete set) | Updated: 22 June 2010.
SIGLO database
Data Group [Ar]: From compilation of A.V. Phelps.
e / Ar
Effective E + Ar → E + Ar (m/M = 0.0000136, complete set) | EFFECTIVE MOMENTUM-TRANSFER CROSS SECTION. Updated: 6 June 2011.
Excitation E + Ar → E + Ar*(11.5eV) (E = 11.5 eV, complete set) | All excitation is grouped into this one level. Updated: 23 June 2010.
Ionization E + Ar → E + E + Ar+ (E = 15.8 eV, complete set) | RAPP-SCHRAM. Updated: 2 March 2010.
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Elastic E + Ar → E + Ar (m/M = 0.0000136, complete set) | elastic momentum transfer from Magboltz 8.97 Sept 2011. Note that the energy resolution in the LXCat tables for energy < 1 eV is less than for the original data. Updated: 3 October 2014.
Excitation E + Ar → E + Ar(1S5) (E = 11.548 eV, complete set) | from Magboltz 8.97 Sept 2011. Updated: 20 October 2011.
Excitation E + Ar → E + Ar(1S4) (E = 11.624 eV, complete set) | from Magboltz 8.97 Sept 2011. Updated: 20 October 2011.
Excitation E + Ar → E + Ar(1S3) (E = 11.723 eV, complete set) | from Magboltz 8.97 Sept 2011. Updated: 20 October 2011.
Excitation E + Ar → E + Ar(1S2) (E = 11.828 eV, complete set) | from Magboltz 8.97 Sept 2011. Updated: 20 October 2011.
Excitation E + Ar → E + Ar(2P10) (E = 12.907 eV, complete set) | from Magboltz 8.97 Sept 2011. Updated: 20 October
STEP 6: SELECT PROCESSES & CLICK NEXT
« PREV
NEXT »
SELECT ALL & FILTER TOOL
no filter

USERS MUST AGREE TO THE TERMS OF USE TO ACCESS DATA (BROWSE AND DOWNLOAD)

YES, I have read and understood »

## Terms of use

Users acknowledge understanding that LXCAT is a community-based project with open-access databases being free, provided by individual contributors.

**Proper referencing of material retrieved from this site is essential for the survival of the project.**

Users further accept that the databases on this site remain property of their respective contributors and are not to be distributed by third parties or used for commercial purposes. All questions regarding copyright should be addressed to the LXCAT team.

## How to reference data

Use of the data from this site in publications should be accompanied by proper references. Original references should be used where possible and reference should be made to the specific database(s) from which data were retrieved, the LXCat site address, and the retrieved date. Example:

> **Urquijo** database, www.lxcat.net, retrieved on October 24, 2014.

## How to reference on-line calculations

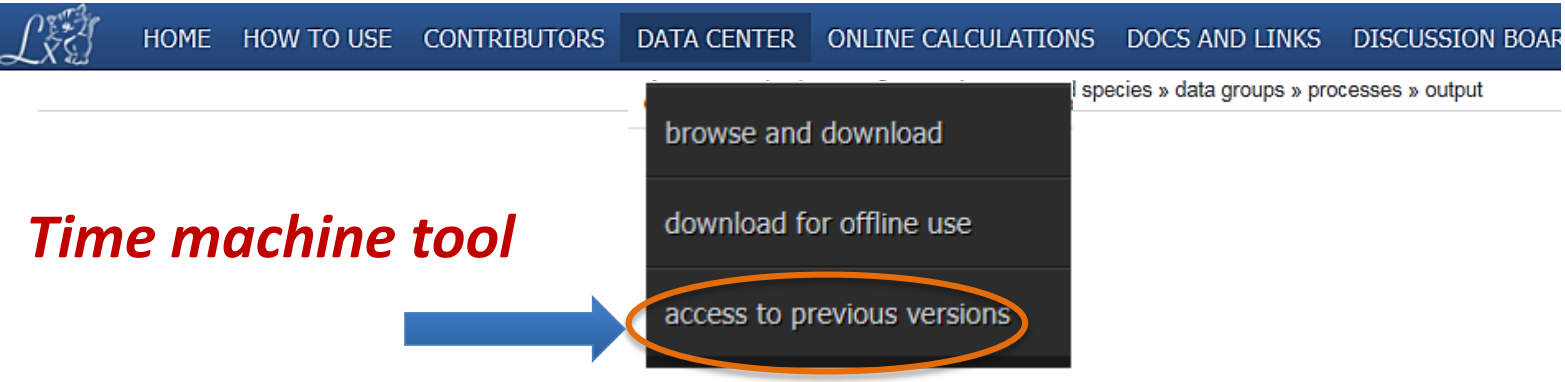
Swarm coefficient calculated on this site should make reference to both the cross section data in the above format and to BOLSIG+, the Boltzmann solver used in the calculations:

> **G.J.M. Hagelaar** and **L.C. Pitchford**, "Solving the Boltzmann equation to obtain electron transport coefficients and rate coefficients for fluid models", Plasma Sci Sources and Tech 14, 722 (2005).

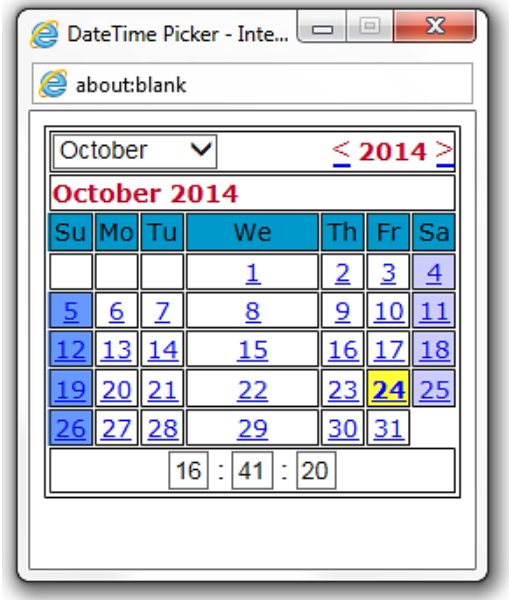
## How to reference text documents

Publications and conference proceedings should be referenced according to journal specifications. All unpublished material on this site should be referenced as **"private communication"** with the date given on the document, the author's name, date, and the retrieved date. Example:

> **Itikawa** database, private communication, www.lxcat.net, retrieved on October 24, 2014.

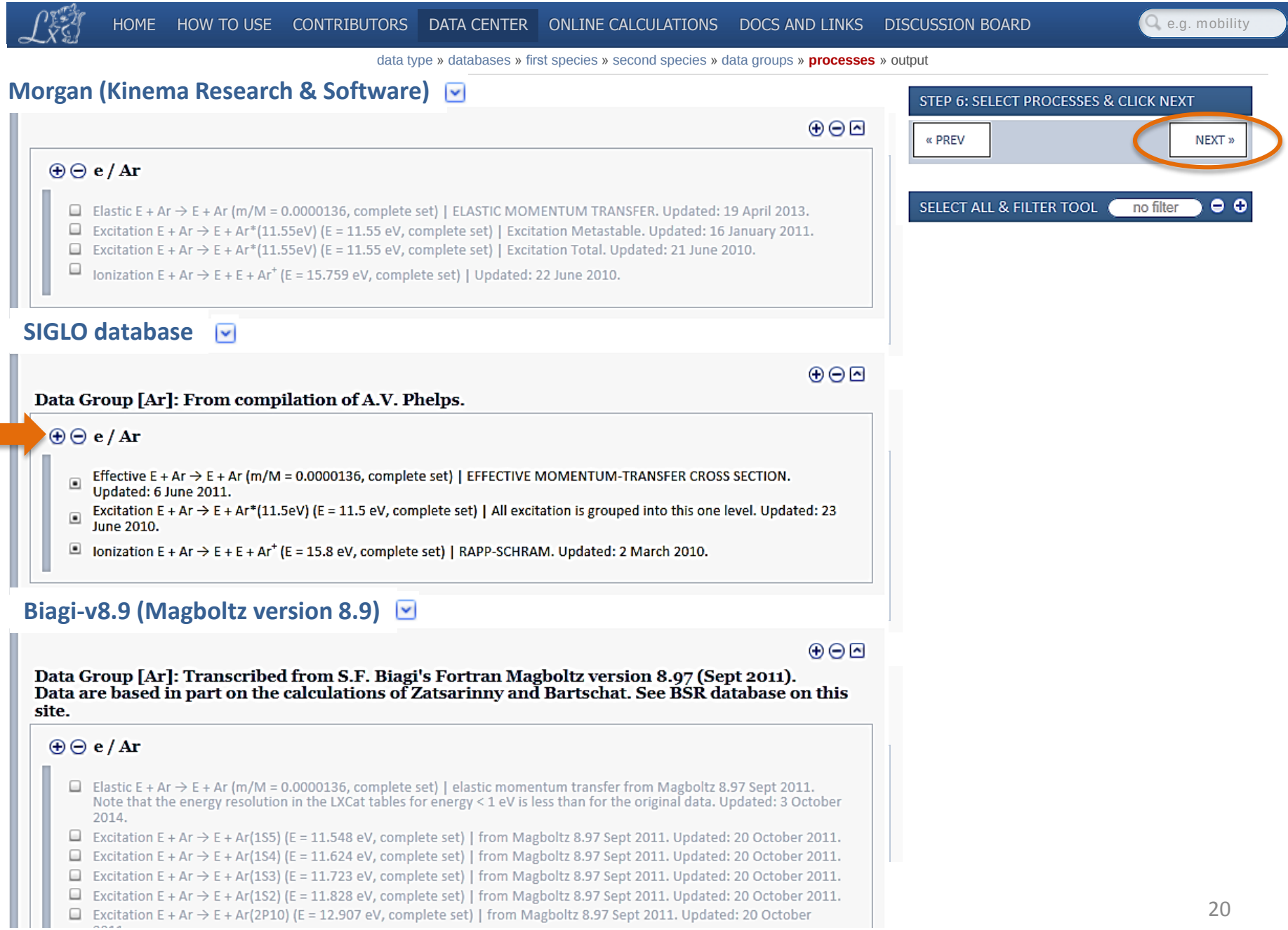



## *Time machine tool*




Put in place on Nov 12, 2013. All changes in the databases since that time are recorded and data can be recovered as they existed on any day since then.

Important for referencing!!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Ionization E + Ar → E + E + Ar+ (E = 15.759 eV, complete set) | Updated: 22 June 2010.
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Excitation E + Ar → E + Ar*(11.5eV) (E = 11.5 eV, complete set) | All excitation is grouped into this one level. Updated: 23 June 2010.
Ionization E + Ar → E + E + Ar+ (E = 15.8 eV, complete set) | RAPP-SCHRAM. Updated: 2 March 2010.
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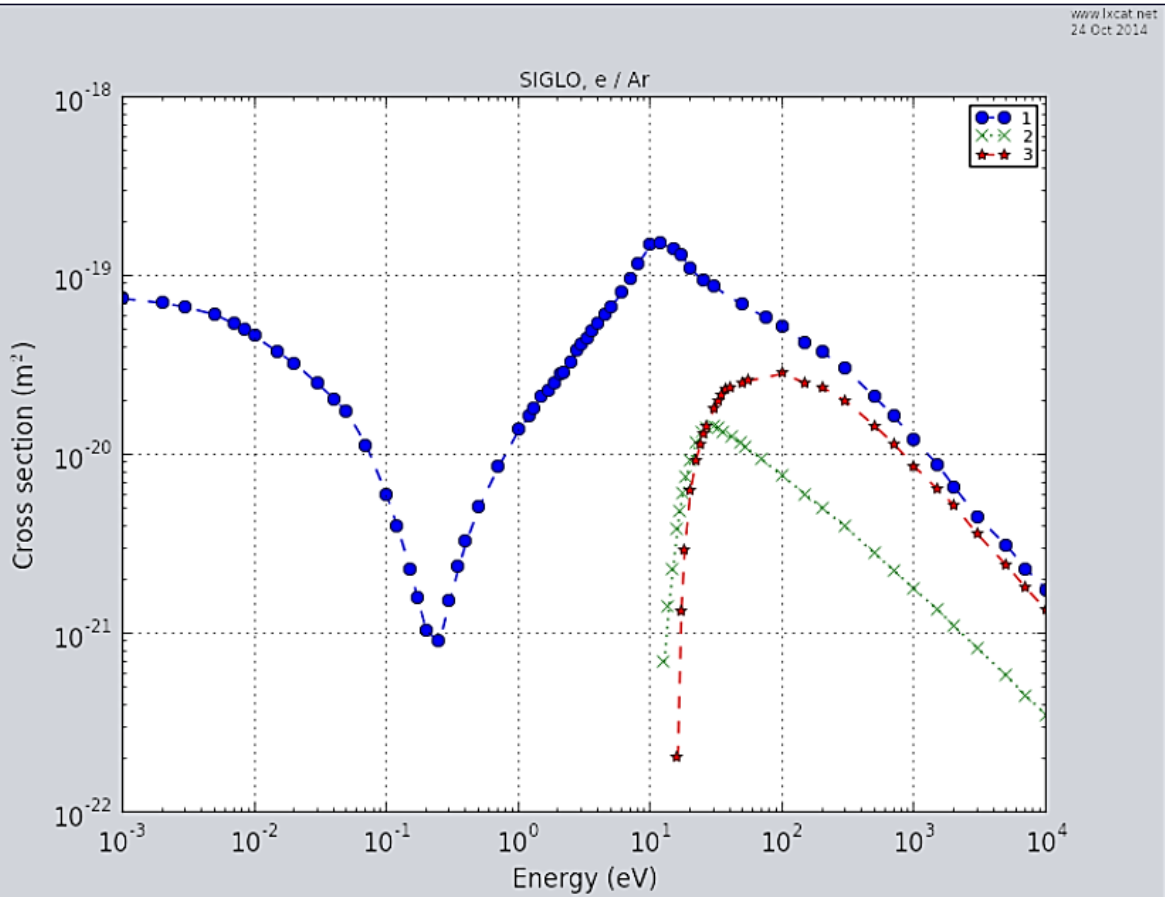
SELECT ALL & FILTER TOOL
no filter

# Cross section

GO BACK | KEEP WINDOW AND GO BACK | RESCALE IN NEW WINDOW | DOWNLOAD IMAGE | DOWNLOAD DATA




## SIGLO database

### Data Group [Ar]

From compilation of A.V. Phelps.

**e / Ar**

**1.** Effective E + Ar → E + Ar (m/M = 0.0000136, complete set) | EFFECTIVE MOMENTUM-TRANSFER CROSS SECTION. Updated: 6 June 2011.

**2.** Excitation E + Ar → E + Ar*(11.5eV) (E = 11.5 eV, complete set) | All excitation is grouped into this one level. Updated: 23 June 2010.

**3.** Ionization E + Ar → E + E + $Ar^+$ (E = 15.8 eV, complete set) | RAPP-SCHRAM. Updated: 2 March 2010.

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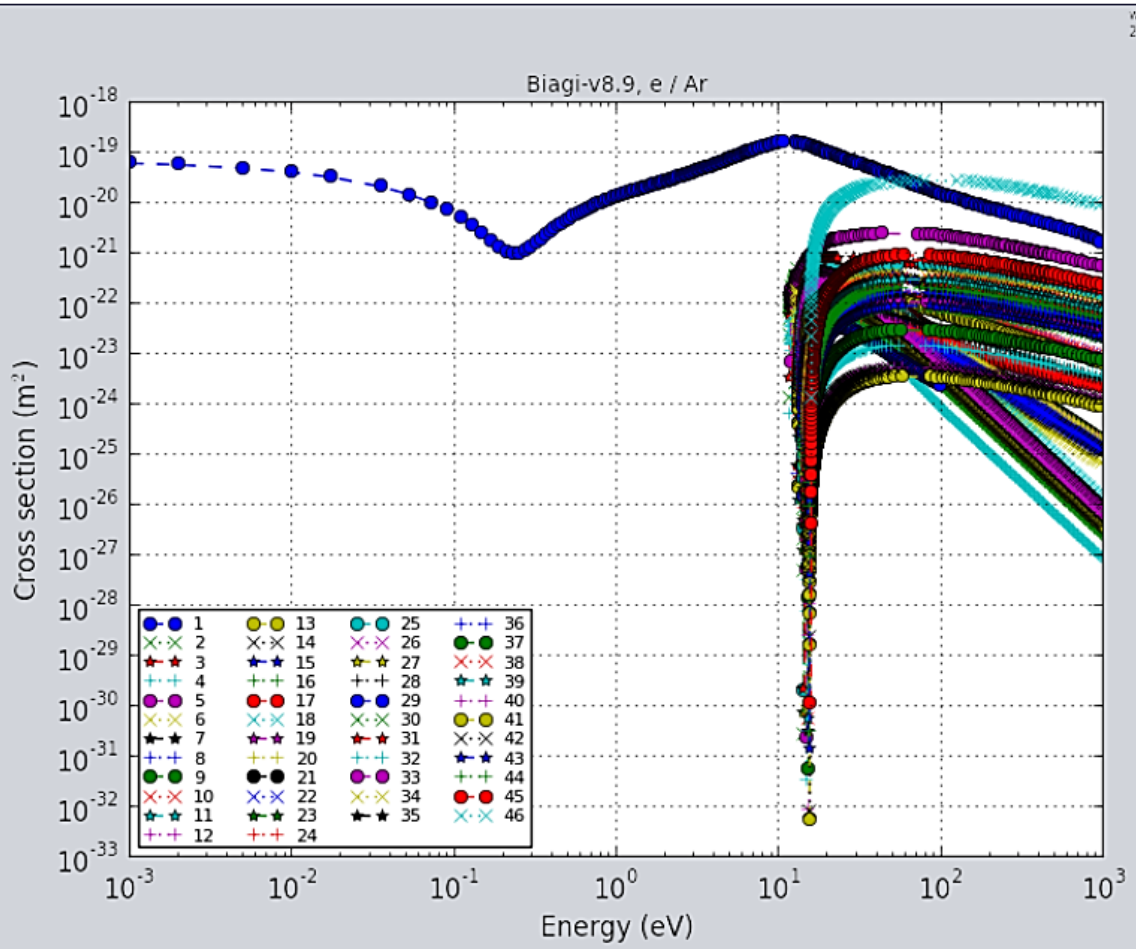


## Biagi-v8.9 (Magboltz version 8.9)

### Data Group [Ar]
### e / Ar

1. Elastic E + Ar → E + Ar (m/M = 0.0000136, complete set) | elastic momentum transfer from Magboltz 8.97 Sept 2011. Note that the energy resolution in the LXCat tables for energy < 1 eV is less than for the original data. Updated: 3 October 2014.
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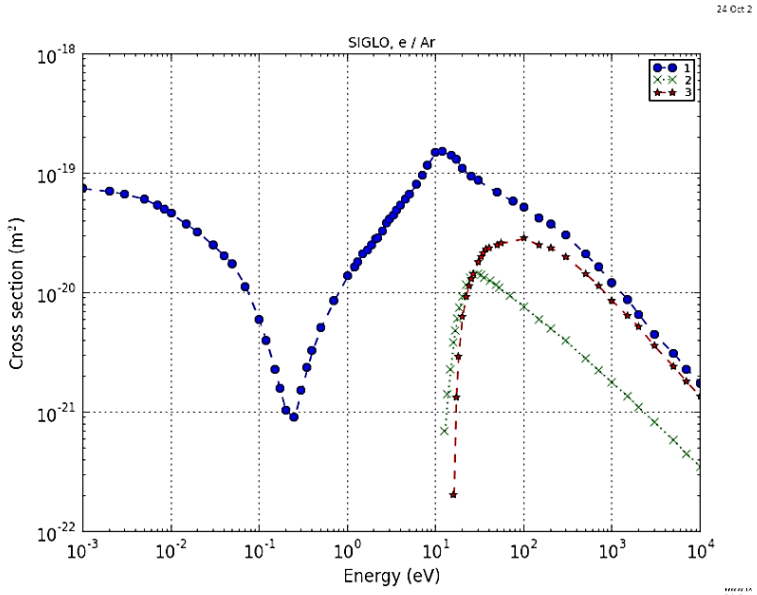
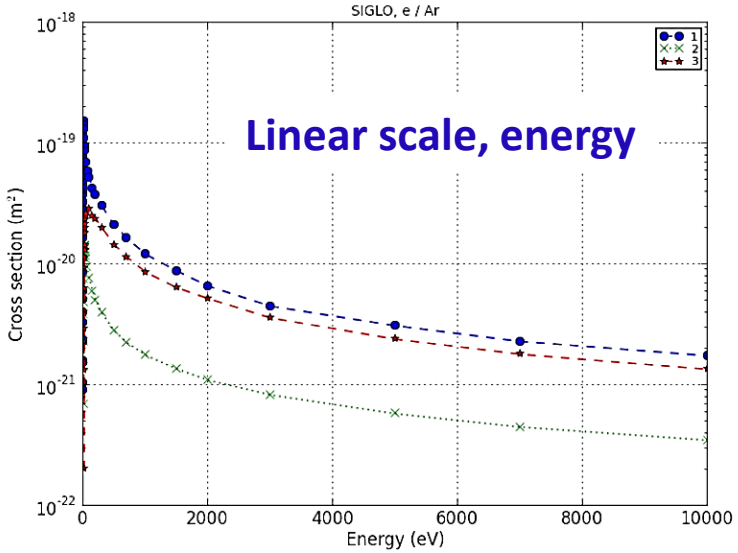
6. Excitation E + Ar → E + Ar(2P10) (E = 12.907 eV, complete set) | from Magboltz 8.97 Sept 2011. Updated: 20 October 2011.
7. Excitation E + Ar → E + Ar(2P9) (E = 13.076 eV, complete set) | from Magboltz 8.97 Sept 2011. Updated: 20 October 2011.
8. Excitation E + Ar → E + Ar(2P8) (E = 13.095 eV, complete set) | from Magboltz 8.97 Sept 2011. Updated: 20 October 2011.
9. Excitation E + Ar → E + Ar(2P7) (E = 13.153 eV, complete set) | from Magboltz 8.97 Sept 2011. Updated: 20 October 2011.
10. Excitation E + Ar → E + Ar(2P6) (E = 13.172 eV, complete set) | from Magboltz 8.97 Sept 2011. Updated: 20 October 2011.
11. Excitation E + Ar → E + Ar(2P5) (E = 13.273 eV, complete set) | from Magboltz 8.97 Sept 2011. Updated: 20 October 2011.
12. Excitation E + Ar → E + Ar(2P4) (E = 13.283 eV, complete set) | from Magboltz 8.97 Sept 2011. Updated: 20 October 2011.
13. Excitation E + Ar → E + Ar(2P3) (E = 13.302 eV, complete set)

# Download TXT, Download PNG, Browse, Re-scale




## Acsii text file for off-line use

## file header

```
LXCat, www.lxcat.net
Generated on 24 Oct 2014. All rights reserved.

RECOMMENDED REFERENCE FORMAT
- SIGLO database, www.lxcat.net, retrieved on October 24, 2014.

CROSS SECTION DATA FORMAT
In downloaded files, each collision process is defined by a block consisting of
1st line
Keyword in capitals indicating the type of the collision. Possible collision types are elastic, effective, excitation,
ionisation, or attachment (capital letters required, key words are case sensitive), where "elastic" is used to denote
the elastic momentum transfer cross section and where "effective" denotes the total momentum transfer cross section (sum
of elastic momentum transfer and total inelastic cross sections).  The latter is useful for solving the Boltzmann
equation in the 2-term approximation.
2nd line
Name of the target particle species. This name is a character string, freely chosen by the user, e.g. "Ar". Optionally
for excitation processes, the name of the corresponding excited state can be specified on the same line, separated from
the first name either by arrow "->" (dash + greater than) or by double-head arrow "<->" (less than + dash +
greater than), e.g. "Ar -> Ar*" and "Ar <-> Ar*", respectively. In the later case BOLSIG+ will automatically
define the inverse superelastic process, constructing the superelastic cross-section by detailed balancing, and
considering the indicated excited state as the target. In this case, the ratio of statistical weights must be input in
the 3rd line (see below).  Alternatively, superelastic collisions could be defined explicitly as excitation collisions
with a negative electron energy loss with user input cross sections and species name, "Ar*", for example.
3rd line
For elastic and effective collisions, the ratio of the electron mass to the target particle mass. For excitation or
ionization collisions, the electron energy loss (nominally the threshold energy) in eV. For attachment, the 3rd line is
missing. In case of an excitation process where an excited state has been indicated on the 2nd line using double-head
arrow "<->", the 3rd line must specify also ratio of the statistical weights of the final state to the initial state
as the second parameter in 3rd line this is needed by BOLSIG+ to calculate the de-excitation cross-section.
from 4th line (optionally)
User comments and reference information, maximum 100 lines. The only constraint on format is that these comment lines
must not start with a number.
Finally
Table of the cross section as a function of energy. The table starts and ends by a line of dashes "------" (at least 5),
and has otherwise two numbers per line: the energy in eV and the cross section in m2.

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
DATABASE:          SIGLO database
DESCRIPTION:       The SIGLO database is the "in-house" data  used by the group GREPHE at LAPLACE in Toulouse. The data
                   are taken from different sources as indicated for each gas. Please refer to original sources in
                   publications.
                   An early version of this data file, "siglo.sec", was distributed with BOLSIG.  The main changes in the
                   present version are :
                   The format has been changed to be compatible with BOLSIG+.
                   Scale factors have been incorporated in the data and no longer appear explicitly.
                   He : The present data are from the compilation of A.V. Phelps (see reference in the Phelps data
                   base).
                   O2 : We recommend using the data in the Phelps database for this species.
                   H2 : We recommend using the data in the Phelps database for this species.
                   Cl2 : The present data are an updated compilation (Jan 2012) by J Gregorio and LC Pitchford.
                   Cu : Feb 2012. Digitised from Tkachev A N, Fedenev A A and Yakovlenko S I, Laser Phys. vol.17, p. 775
                   (2007)
                   Kr :  Nov 2012.  We re-digitised the data from figs. 1 and 5 in H. Date, Y. Sakai and H. Tagashira, J.
                   Phys. D 22 1478 (1989).  With respect to the previous data from this same reference in the SIGLO
                   database, there are some changes in the threshold values and in the magnitudes of the inelastic cross
                   sections.
CONTACT:           LC Pitchford and JP Boeuf
                   pitchford@@laplace.univ-tlse.fr and jpb@@laplace.univ-tlse.fr
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

**********************************************************************************************************************

COMMENT: From compilation of A.V. Phelps.

EFFECTIVE
Ar
 1.360000e-5
SPECIES: e / Ar
PROCESS: E + Ar -> E + Ar, Effective
PARAM.:  m/M = 0.0000136, complete set
COMMENT: EFFECTIVE MOMENTUM-TRANSFER CROSS SECTION.
UPDATED: 2011-06-06 18:21:14
COLUMNS: Energy (eV) | Cross section (m2)
-----------------------------
 0.000000e+0     7.500000e-20
 1.000000e-3     7.500000e-20
 2.000000e-3     7.100000e-20
 3.000000e-3     6.700000e-20
 5.000000e-3     6.100000e-20
```

## Data tables

Check time!


RESET UPDATE LIST OF SPECIES

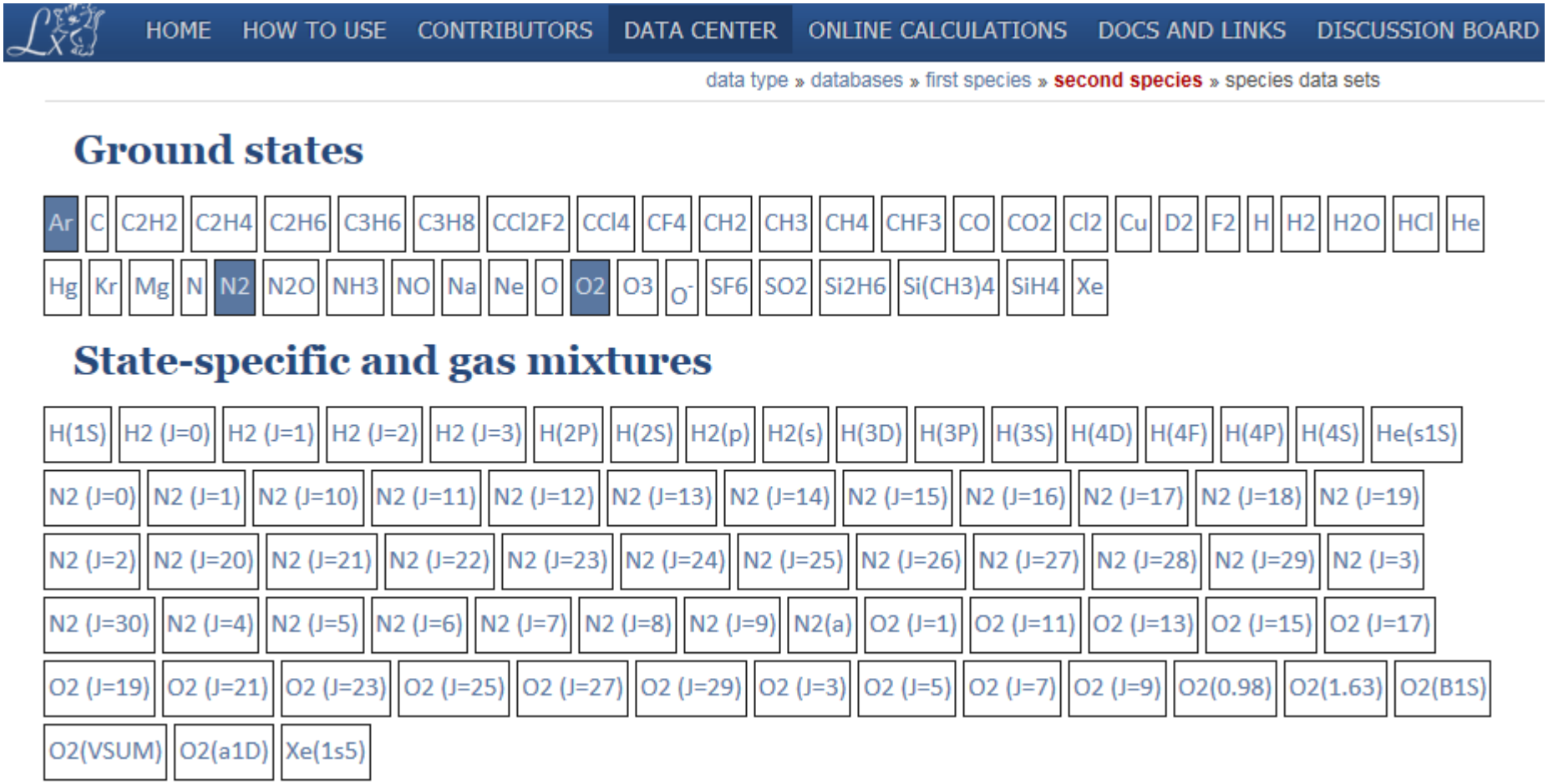
# About the solver

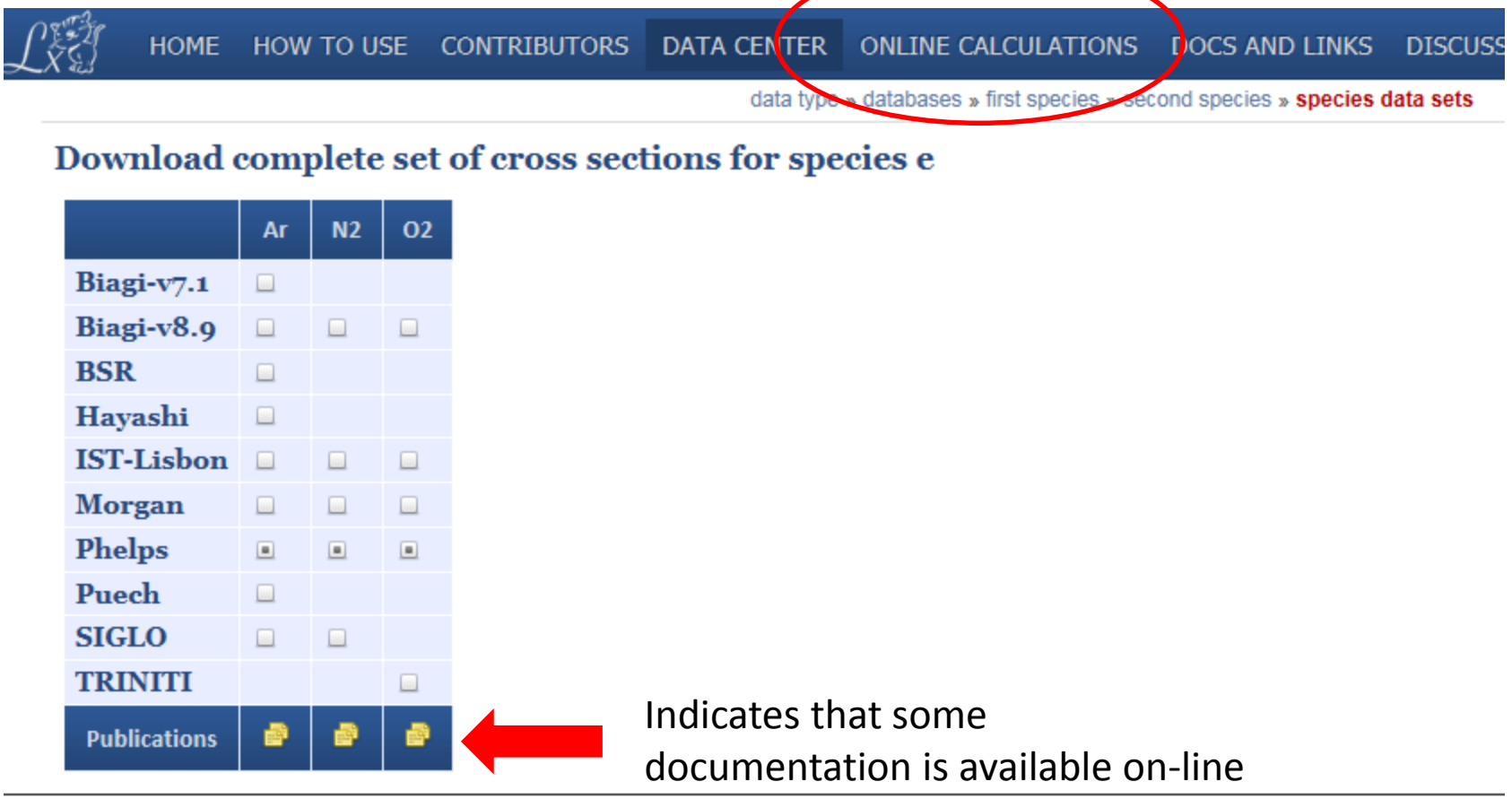
Swarm parameters are calculated here using BOLSIG+ (ver. 1.2) solver for the numerical solution of the Boltzmann equation for electrons in weakly ionized gases in uniform electric fields, conditions which typically appear in the bulk of collisional low-temperature plasmas. It has been developed by Gerjan Hagelaar (LAPLACE, France).

Note that BOLSIG+ makes use of the classical "2-term approximation". Some of the data sets on this site were developed for use with Monte Carlo or "multiterm" Boltzmann solvers and errors may be introduced by the 2-term approximation used in BOLSIG+. We have tried to indicate when this could be of concern. Please consult BOLSIG+ for the details and to download the complete freeware application for Windows.

Users of this site are kindly requested to reference to BOLSIG+ and the appropriate cross section databases in all publications making use of data from this site.

# Select components of gas mixture






2012-11-08 Preview | Open | Download

**Comparisons of sets of electron-neutral scattering cross sections and calculated swarm parameters in N2 and O2** by LC Pitchford, S Chowdhury, GJM Hagelaar, S Pancheshnyi, MC Bordage , LL Alves , V Guerra, CM Ferreira, SF Biagi, Y Itikawa, I Kochetov, A Napartovich, AV Phelps.

**Abstract:** We present a description of the sets of electron-neutral scattering cross sections for N2 (4 sets) and for O2 (4 sets) presently available on the open-access LXCat site (www.lxcat.net). Three of these sets are complete in that the main momentum and energy loss processes are taken into account, if we can neglect internal excitation in the gas, and were derived using the requirement that they be consistent with available experimental swarm data. The fourth set consists of recommended values from beam experiments and theory. We describe these cross section sets and show, for each, comparisons of calculated swarm parameters with selected experimental data.

**Reference:** conference paper.

RESET UPDATE LIST OF SPECIES RUN CALCULATIONS »

# About the solver

Swarm parameters are calculated here using BOLSIG+ (ver. 1.2) solver for the numerical solution of the Boltzmann equation for electrons in weakly ionized gases in uniform electric fields, conditions which typically appear in the bulk of collisional low-temperature plasmas. It has been developed by Gerjan Hagelaar (LAPLACE, France).

Note that BOLSIG+ makes use of the classical "2-term approximation". Some of the data sets on this site were developed for use with Monte Carlo or "multiterm" Boltzmann solvers and errors may be introduced by the 2-term approximation used in BOLSIG+. We have tried to indicate when this could be of concern. Please consult BOLSIG+ for the details and to download the complete freeware application for Windows.

Users of this site are kindly requested to reference to BOLSIG+ and the appropriate cross section databases in all publications making use of data from this site.

A full version of BOLSIG+ with many more options (e-e collisions, high frequency excitation, ExB,..) is available as freeware.

CONFIG

◉ non-Maxwellian EEDF | ○ Maxwellian EEDF

E/N = 0.1 - 1000 Td

Te = 0.03 - 10 eV

$T_{gas}$ = 300 K # points = 25

SPECIES MOLE FRACTIONS

Ar = 0.333333

N2 = 0.333333

O2 = 0.333333

BROWSE

Electron cross sections (new window)

DOWNLOAD

Cross section input file

# Results available on-line and by download

**BROWSE**

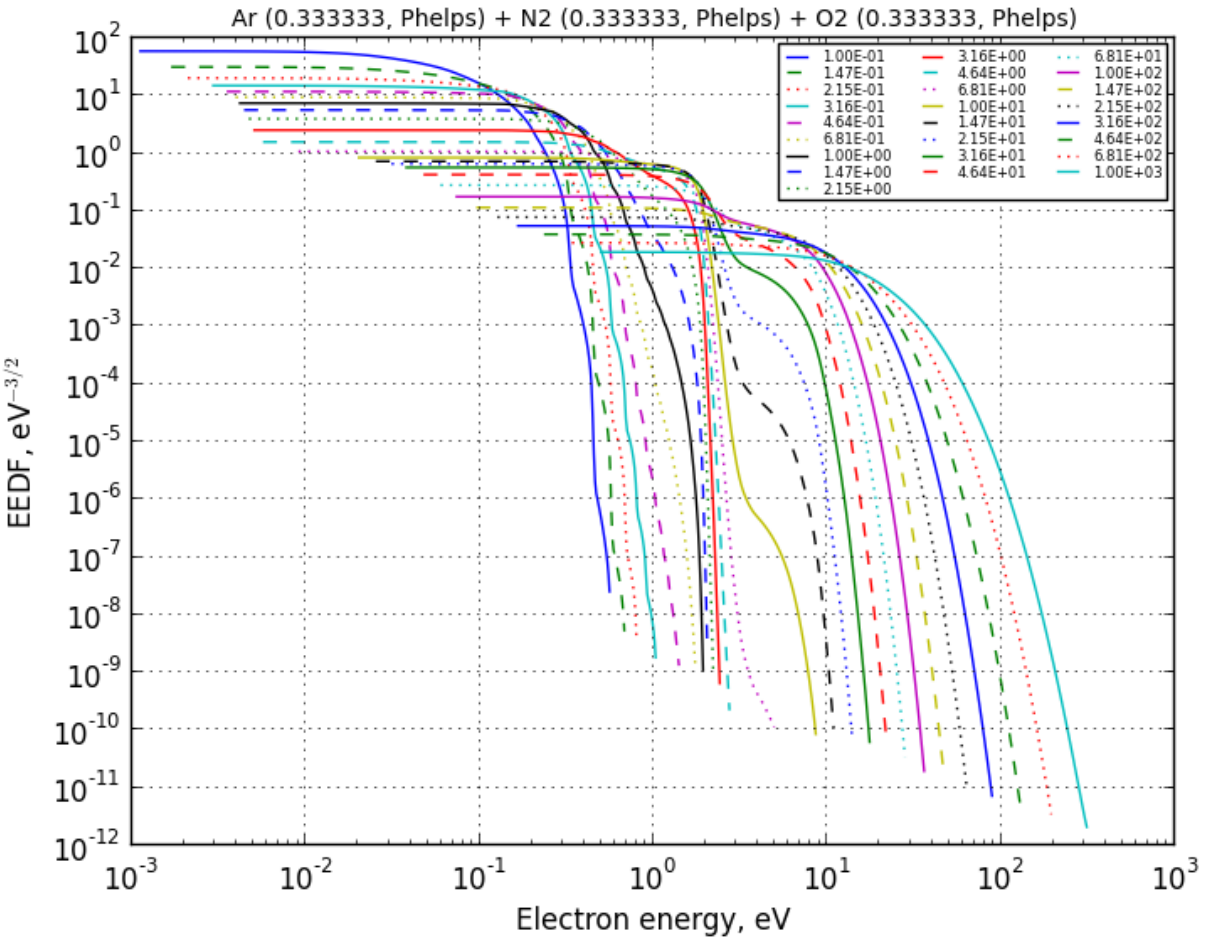
Mobility x Gas density
Diffusion coefficient x Gas density
Reduced Townsend coefficient
Electron energy
Reaction rates
Electron energy distribution functions
Electron cross sections (new window)

**DOWNLOAD**

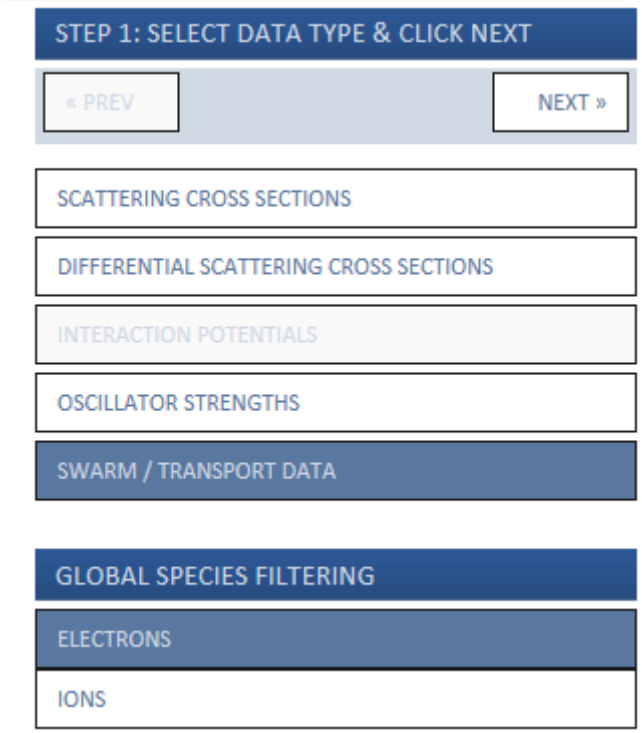
Swarm parameters in text file
All figures in zip archive
Cross section input file

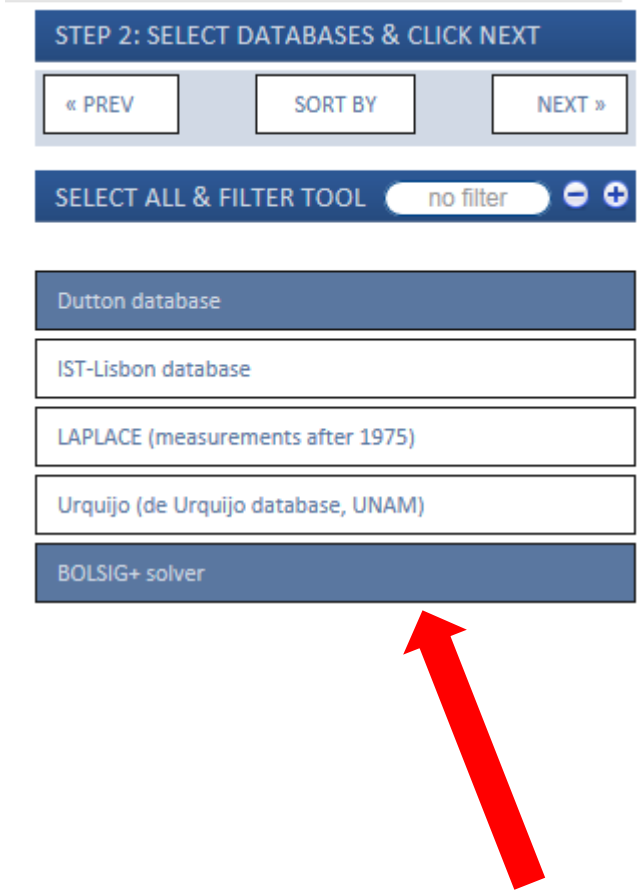
**SAVE DATA FOR FURTHER BROWSING**

Create a temporary LXCat database containing these results



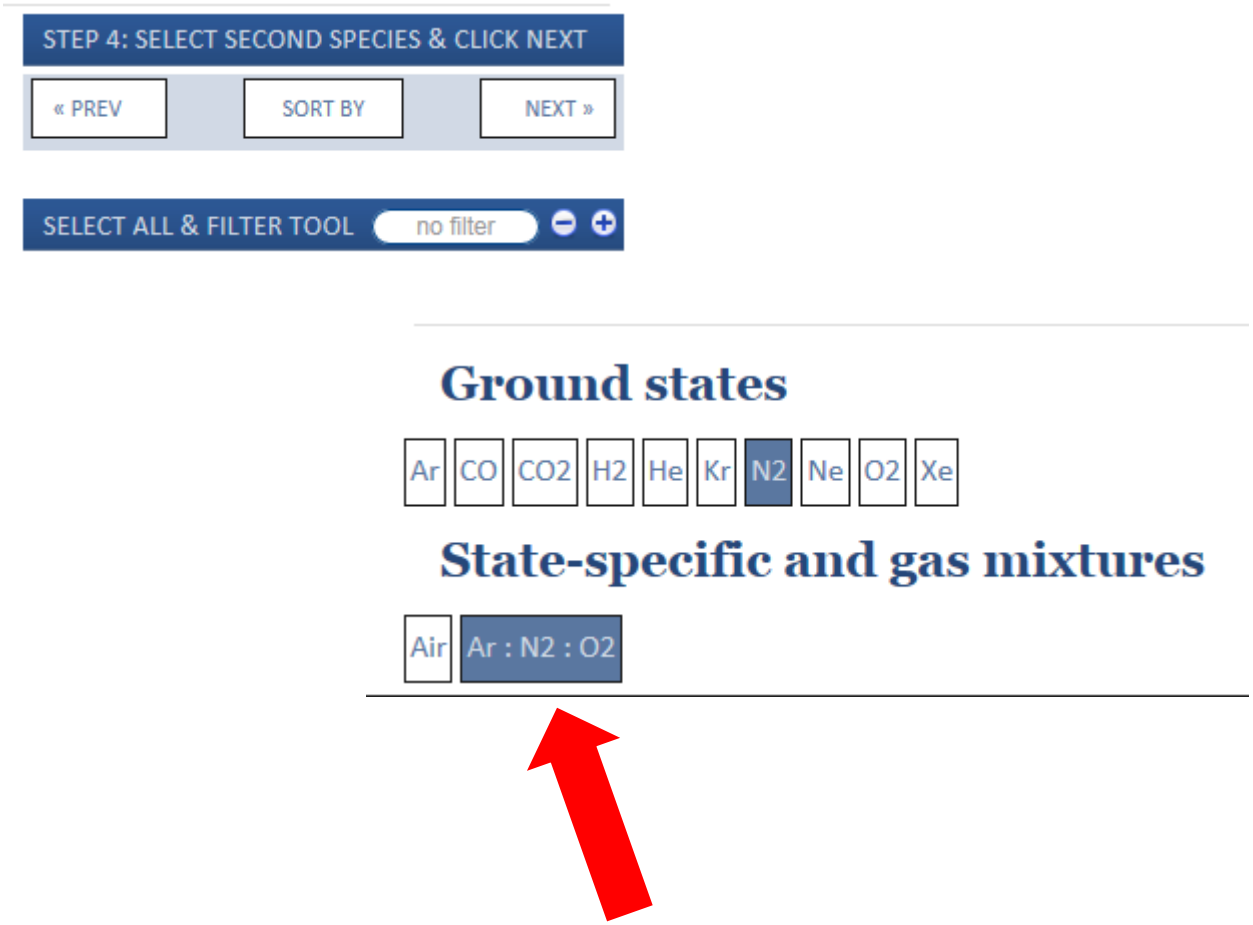
# Compare measured and calculated swarm data




Temporary database containing results from on-line calculations

# Compare measured and calculated swarm parameters




Gas mixture in temporary database

STEP 5: SELECT DATA GROUPS & CLICK NEXT

« PREV NEXT »

SELECT ALL & FILTER TOOL no filter

## Diffusion x gas density

Diffusion x gas density (DN)

## Energy

Characteristic energy (D/μ) Mean energy (ε)

## Energy distribution function

Energy distribution function ($f_0$)

## Mobility x gas density

Mobility x gas density (μN)

## Rate coefficient

Reaction rate (k)

STEP 6: SELECT PROCESSES & CLICK NEXT

« PREV NEXT »

SELECT ALL & FILTER TOOL no filter

- Mobility x gas density (μN) | Schlumbohm 1965. Updated: 9 August 2012.
- Mobility x gas density (μN) | Tholl 1964. Updated: 12 October 2012.
- Mobility x gas density (μN) | Wagner 1962. Updated: 12 October 2012.
- Mobility x gas density (μN) | Wagner 1964. Updated: 12 October 2012.
- Mobility x gas density (μN) (Tgas = 77 K) | Pack, et al 1961. Updated: 26 September 2013.
- Mobility x gas density (μN) (Tgas = 195 K) | Pack, et al 1961. Updated: 26 September 2013.
- Mobility x gas density (μN) (Tgas = 473 K) | Hendrick, et al. Updated: 26 September 2013.

## BOLSIG+ solver

**Data Group [Ar0333333PhelpsN20333333PhelpsO20333333Phelps]: Tgas 300 K**
**EEDF 1 (type of EEDF : 1 = non-Maxwellian)**
**ENmin 0.1 Td**
**ENmax 1000 Td**
**points 25**
**Ar 0.333333 Phelps database**
**N2 0.333333 Phelps database**
**O2 0.333333 Phelps database.**

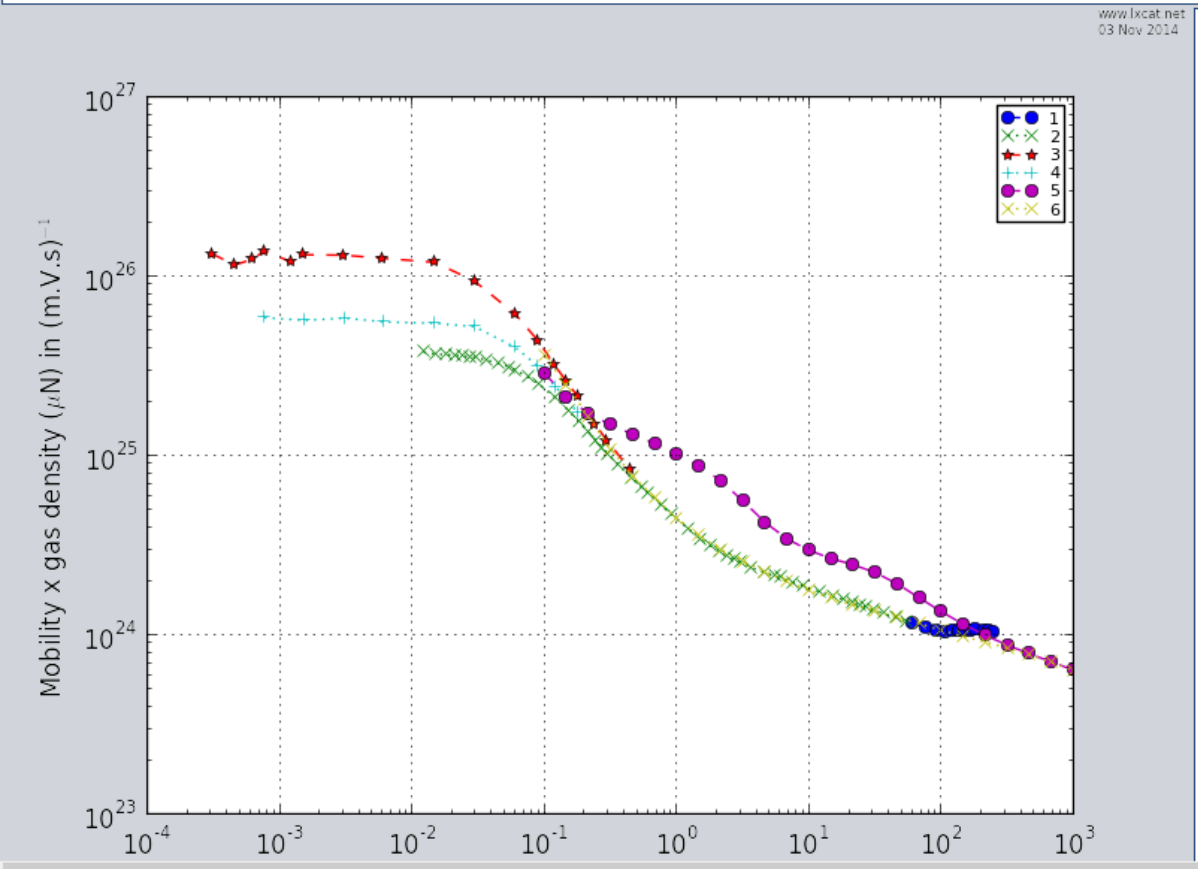
### e / Ar : N2 : O2

#### e / Ar : N2 : O2 (0.333333 : 0.333333 : 0.333333)

- Mobility x gas density (μN) | Updated: 3 November 2014 4:23:18.

# Mobility x gas density

GO BACK | KEEP WINDOW AND GO BACK | RESCALE IN NEW WINDOW | DOWNLOAD IMAGE | DOWNLOAD DATA




## Dutton database

**Data Group [SwarmGroup12]**
**e / N2**

1. Mobility x gas density (μN) | Blevin, et al 1967. Updated: 12 October 2012.
2. Mobility x gas density (μN) | Lowke 1963. Updated: 12 March 2012.
3. Mobility x gas density (μN) (Tgas = 77 K) | Pack, et al 1961. Updated: 26 September 2013.
4. Mobility x gas density (μN) (Tgas = 195 K) | Pack, et al 1961. Updated: 26 September 2013.

## BOLSIG+ solver

**Data Group [Ar0333333PhelpsN20333333PhelpsO20333333Phelps]**
**e / Ar : N2 : O2**
**e / Ar : N2 : O2 (0.333333 : 0.333333 : 0.333333)**

5. Mobility x gas density (μN) | Updated: 3 November 2014 4:23:18.

**Data Group [N21Phelps]**
**e / N2**
**e / N2 (1)**

6. Mobility x gas density (μN) | Updated: 3 November 2014 4:36:55.

# GEC Plasma Data Exchange Project => evaluation

## Cluster issue : 2013 *J. Phys. D: Appl. Phys.* **46** Issue 33

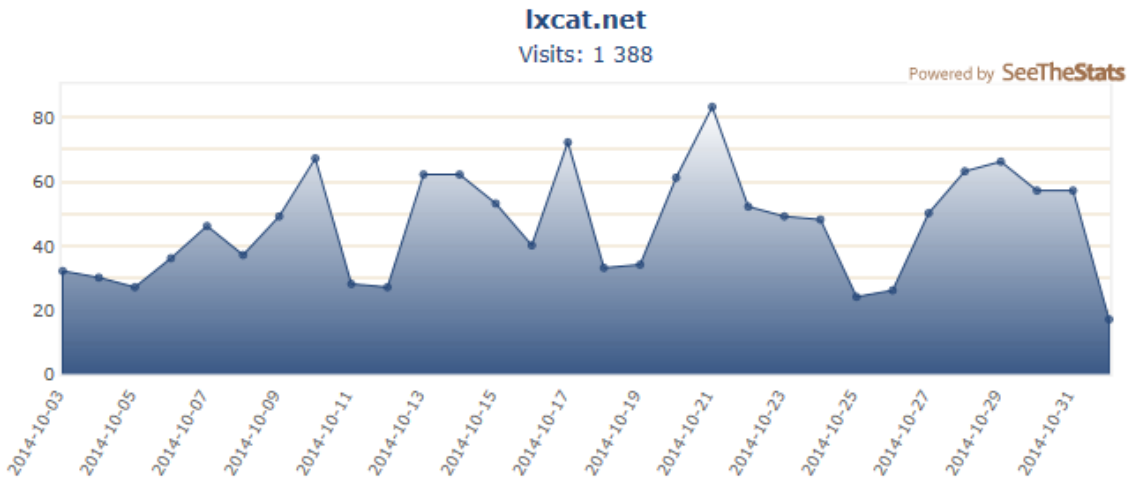
*Paper I:* ***Comparisons*** **of sets of electron-neutral scattering cross sections and swarm parameters in noble gases I. Argon** LC Pitchford, Alves LL, Bartschat K, Biagi SF, Bordage MC, Phelps AV, Ferreira CM, Hagelaar GJM, Morgan WL, Pancheshnyi S, Puech V, Stauffer A and Zatsarinny O

*Paper II:* ***Comparisons*** **of sets of electron-neutral scattering cross sections and swarm parameters in noble gases II. Helium and Neon** LL Alves, Bordage MC, Biagi SF, Pitchford LC, Zatsarinny O, Bartschat K, Hagelaar GJM, Pancheshnyi S, Ferreira CM, Puech V, Morgan WL and Phelps AV

Paper III: **Comparisons of sets of electron-neutral scattering cross sections and swarm parameters in noble gases III. Krypton and Xenon** MC Bordage, SF Biagi, LC Pitchford, K Bartschat, S Chowdhury, GJM Hagelaar, WL Morgan, V Puech, O Zatsarinny

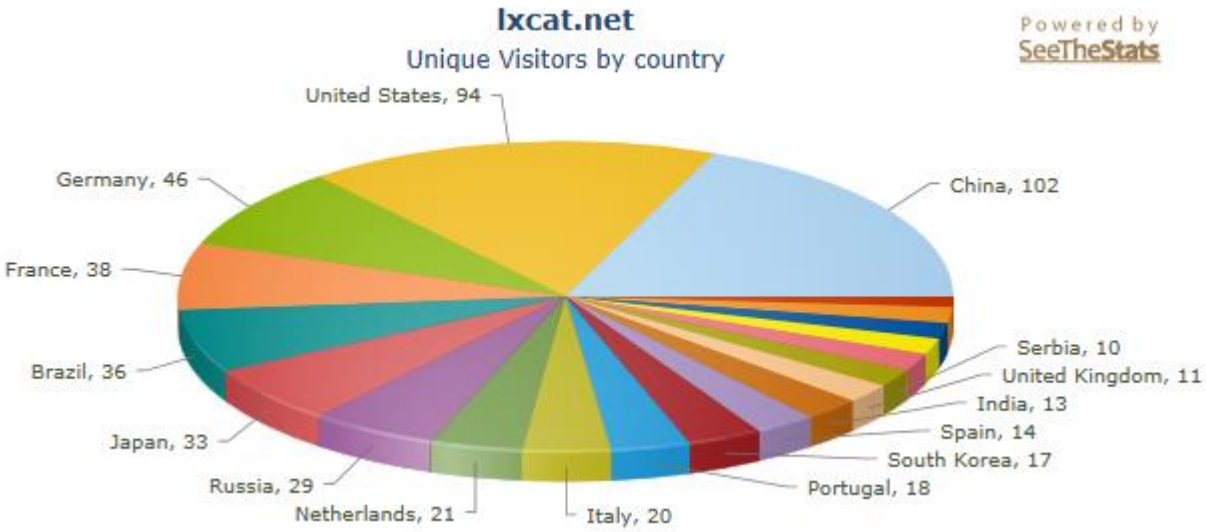
Paper IV: **Computational Methods for Electron-Atom Collisions in Plasma Applications** K. Bartschat

# LXCAT: some statistics




**An average of unique visitors per day**

**Where are they from?**



# Future directions

- **Continuing the enlargement of the databases, on-line tools**

  new contributors, new data types

- **Giving contributors proper recognition for their work**

  consistent format for referencing among editors

- **Continuing effort on evaluation of data**

  some evaluations have been published, others have been presented at the GEC and will be published, & work is in progress for other molecules

- **Structure, funding, connection to other sites (e.g. VAMDC)**

**To contribute, please contact lxcat.info@gmail.com**