# The new nebular software

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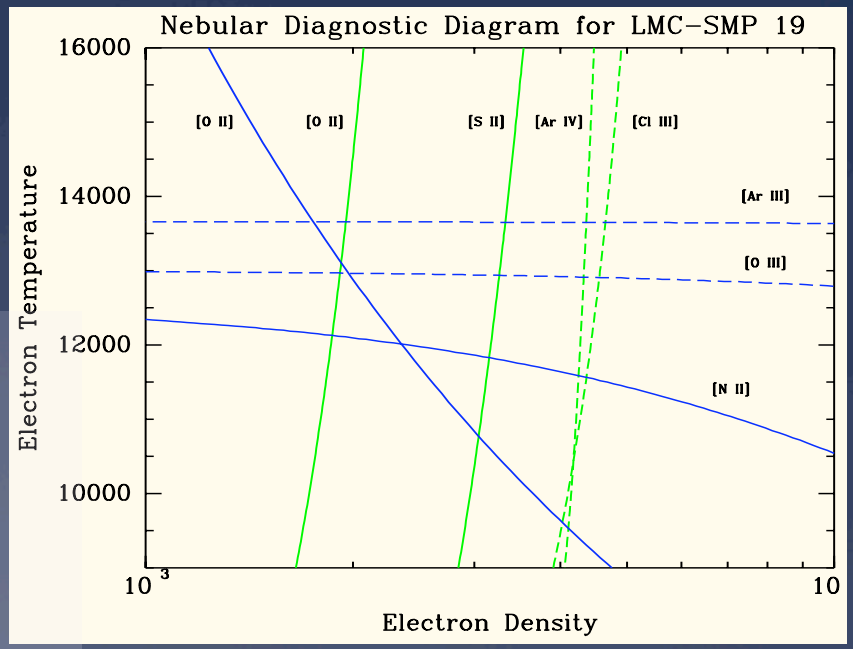
# the current nebular

Nebular is a package for the analysis of emission lines:

- flux ratios -> $T_e$, $N_e$
- $T_e$, $N_e$ -> emissivities
- $T_e$, $N_e$, flux -> chemical abundances




nebular is conceptually simple but has powerful features, e.g.:

- input atomic data not hardwired
- user can select line ratio to be used
- choice of interstellar extinction law

# the future nebular - I

- Migrate nebular from spp to python
- Add new ions, including s-process elements
- Add IR lines to selectable line ratios
- Allow simultaneous determinations of $N_e$ and $T_e$ from pairs of line ratios
- Determine ionic abundances for He and other elements from recombination lines
- Perform error analysis of $N_e$, $T_e$, and abundances

# the future nebular - II

* Add recipes for computing total elemental abundances from ionic abundances, using common or user-defined ICF formulae
* Create VO-compatible web services to provide nebular over the internet.
* Organize the atomic reference data in an efficient way
* Provide code with an extensive documentation, adapted to different kinds of user

# why python? - I

- Free, well-documented, supported
- Portable
- Scripting language: can be embedded within HTML to add functionalities to web pages
- Powerful: built-in object types library
- Interface with fits
- GUI programming

# why python? - II

* object-oriented:
  - emphasis on data+methods rather than procedures;
  - flexibility in definition of data objects
  - data encapsulation and abstraction
  - modularity
  - modifiability

the user has direct access to internal objects

"Atom" class:

```
{'number': 2,
'name': 'oxygen',
'gsconfig': 'p3',
'filename': 'o_ii.fits',
'nlevel': 5,
'cs': [[0.864, 0.59, 0.299, 0.148, ...],
       [0.5, 0.885, 0.587, 0.307, ...],
       [...], [...]],
...}
```

# data format

## Input atomic data are in fits

Two separate fits files:

- x_ion_atom.fits:
  energy levels
  As
- x_ion_coll.fits:
  effective collision strengths

One fits file:

x_ion.fits

- x_ion[0]: atom description
  # FILENAME 's_ii.fits'  name of file
  # ATOM  sulfur
  # SPECTRUM 2
  # N_LEVELS 5
  # GSCONFIG p3
- x_ion[1]: atomic data
- x_ion[2]: collisional data

# atomic reference data

effort to organize the atomic data in an efficient way:

- build the database from the atomic datafile
- retrieve the paper or table
- Allows users to implement alternative sources
- compare with default choice of other codes

# documentation

Documentation is key to efficient use and maintenance:

- what the code does (physical problem) and how it does it (algorithms)
- which atomic data are available; how to select a different set of atomic data; how to add new options.
- what has changed with respect to IRAF
- effects of changes in the atomic data at selected points (e.g., typical nebular conditions, T = 10kK and 20kK; extreme conditions)
- content of files: code + atomic database

# concluding remarks

- In which other ways can nebular be useful (e.g. access to class level)?
  - E.g., implementation of interstellar extinction class
- Would it be useful to provide reference emission line fluxes of actual targets:
  - for testing new atomic data?
  - for regression testing of nebular? (yes!)
  - as a reference for novel users?