



**Faculty of Science Institute for Astronomy and Astrophysics** 



# **Model-Atmosphere Spectra** for Central Stars of Planetary Nebulae – Access via the Virtual Observatory Service TheoSSA

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The German Astrophysical Virtual Observatory (GAVO) provides the registered Virtual Observatory (VO) service TheoSSA (Theoretical Stellar Spectra Access). It is dedicated to the easy access of VO users to theoretical stellar spectral-energy distributions, calculated with any model-atmosphere code. In a pilot phase, TheoSSA is based on the well established Tübingen NLTE Model-Atmosphere Package (TMAP) for hot, compact stars.

## TMAP

TMAP (http://astro.uni-tuebingen.de/~TMAP, Werner et al. 2003, Rauch & Deetjen 2003) was created in the 1980s and is continuously developed since then. With TMAP, model atmospheres for hot, compact objects like e.g. central stars of planetary nebulae, PG 1159 stars, and white dwarfs can be calculated. Effective temperatures between 20 kK and more than 10 MK, surface gravities between  $\log g = 4$  and 15 can be chosen and elements from hydrogen to nickel can be included into the calculations. *TMAP* can consider:

- hydrostatic and radiative equilibrium
- plane-parallel or spherical geometry
- $\approx$  1600 atomic levels treated in NLTE
- H K, Ge, Kr, Xe:  $\approx$  10000 individual spectral lines

#### TMAD

The model-atom database TMAD provides ready-to-use model atoms including level energies and radiative and collisional transition data. Presently, it includes the elements H, He, C, N, O, F, Ne, Na, Mg, Si, P, S, Ar, Ca, Ge, Kr, and Xe. They are available for model-atmosphere and SED calculations (the latter include fine-structure splitting).

### **Application to Hot Stars**

TheoSSA contains several grids suitable for the analysis of (F)UV spectra of hot, compact stars, e.g. with a typical PG 1159-type star abundance pattern, i.e. He:C:N:O = 33:50:2:15 by mass (Fig. 2).

• Ca - Ni (iron-group elements):  $\approx$  300 million lines

# **TheoSSA**

TheoSSA uses the International Virtual Observatory Alliance (IVOA) standard SSA (Simple Spectra Access). It is based on TMAP and provides

- SEDs (http://dc.g-vo.de/theossa, Fig. 1)
- Simulation Software
  - (*TMAW*, http://astro.uni-tuebingen.de/~TMAW)
- Atomic Data

(*TMAD*, http://astro.uni-tuebingen.de/~TMAD)

GERMAN ASTROPHYSICAL			
GAVO	TheoSSA	Web Interface	
Help Service info	TheoSSA provides spectral energy distributions based on model atmosphere calculations. Currently, we serve results obtained using the Tübingen NLTE Model Atmosphere Package for hot compact stars.		
Related			
Compute custom SEDs	Effective Temperature [K]	between       100000       and       150000         Range of the atmosphere's effective temperatures to include. If you only specify one bound, you get a half-infinite interval.	
Metadata	Log Surface	between 6 and 8	
Identifier >> Description >>	gravity [cm/s2]	Range of surface gravities to include. If you only specify one bound, you get a half-infinite interval.	
Keywords >> Creator >>	Mass loss rate [solMass/yr]	between 0 and 0 Range of mass loss rates to include. If you only specify one bound, you get a half-infinite interval.	
Created >>	Mass Eraction	ANX . No selection matches all multiple values legal	
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Reference URL >>	Mass Fraction 2	ANY No selection matches all, multiple values legal.	
Try ADQL to query our data.		He     •     between     0.8     and     1.0       Mass fraction of an element. You may leave out either upper or lower bound.	
	Mass Fraction	C No selection matches all, multiple values legal.	
Please report errors and	3		
problems to the <u>site</u> operators. Thanks. <u>Privacy</u>   <u>Disclaimer</u>		Mass fraction of an element. You may leave out either upper or lower bound.	
Log in COVERED BY DATA DATA TATION INDEX	Standard Stars	ANY EG 274 Feige 67	
	Туре	VOTable Text Format of spectrum data files	
	Table	Sort by  Limit to 100  items.	
	Output format	HTML   More output fields	
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	When publishing	research making use of this service, please	

Fig. 1: TheoSSA interface. Fundamental parameters like  $T_{\text{eff}}$ , log g, and abundances can be requested. Note that it is possible to select spectrophotometric standard stars. A table of the available SEDs is then returned. These can be retrieved.



acknowledge: "The TheoSSA service (http://dc.g-vo.org/theo

#### TMAW

If a requested SED is not available, it can be calculated via TMAW. This is the web interface of TMAP. Without detailed knowledge of the stellaratmosphere code, individual SEDs considering opacities of the elements H+He+C+N+O+Ne+Na+Mg can be calculated. The requested parameters and the user's email address have to be entered in the web interface and the result can be downloaded within a few days. It is also possible to calculate extended grids of SEDs on compute resources of AstroGrid-D (http://www.gac-grid.net/).

• Werner, K., et al. 2003, ASP-CS, 288, 31

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