# The Spitzer Atlas of Stellar Spectra (SASS)

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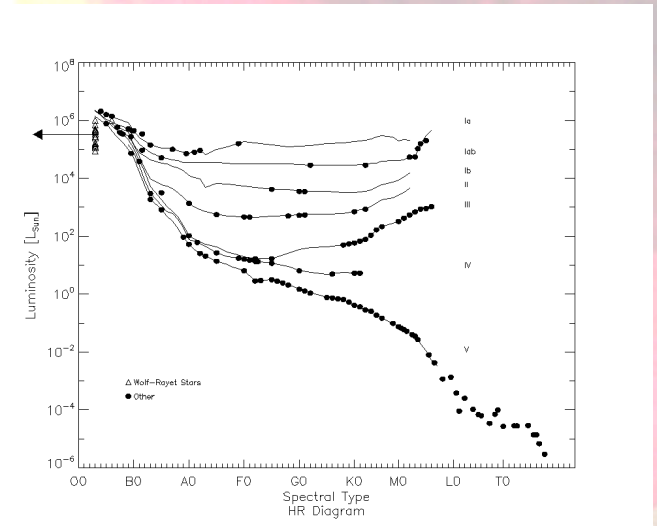



**Summary**: The *Spitzer* Atlas of Stellar Spectra (SASS) consists of 159 stellar spectra (5 to 32 μm; R≈100) taken with the Infrared Spectrograph on the *Spitzer Space Telescope*. It gathers representative spectra of a broad section of the HR diagram, and it is intended to serve as a general stellar spectral reference in the mid-infrared. All the spectra are available online (either from IRSA or from D. Ardila's webpage). The Atlas is described in Ardila et al. 2010, ApJS, submitted.

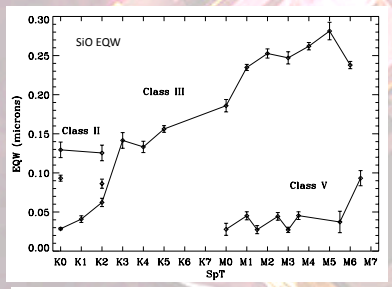
**Target Selection**: Targets were selected from >11,000 IRS staring archival observations, complemented with a cycle 5 DDT proposal. The priority was to include **naked photospheres observed with all IRS modules: SL2, SL1, LL2, and LL1**. However, we also included Wolf-Rayet stars and some stars of intrinsic interest (i.e. Cepheids, blue stragglers) independently of excess. When selecting the targets we avoided objects described as young low-mass stars, RS CVn stars, Be stars, or spectroscopic binaries in the Simbad database. Spectral types were taken from the literature

**Reduction**: The reduction is based on the sky-subtracted products generated by the SSC pipeline 18.7.0. Multiple observations of the same target were averaged, and the orders were scaled to the brightest order. The error in the overall flux level is that of the standard IRS calibration (≈5%). The spectra have not been corrected for interstellar extinction.

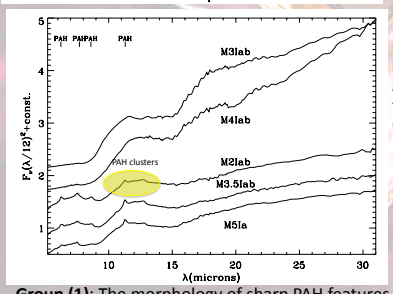
**Left**: The HR diagram presents the contents of the Atlas at a glance. For most stars, luminosities were determined from the spectral type. The diagram is purely illustrative and does not necessarily reflect the true luminosities of the objects.

**Some highlights:** The spectra of most dwarfs and giants without circumstellar material are relatively featureless. With the exception of the Humpreys lines in A dwarfs, atomic absorption lines cannot be generally discerned at the IRS resolution, and the most noticeable photospheric features correspond to water vapor and silicon monoxide in late type dwarfs and giants, as well as methane and ammonia features at the latest spectral types.

**Gravity effects:** For giants, the most noticeable features are the SiO fundamental $v = 1 - 0$ band and the $H_2O$ $\nu_2$ band around 6.75 μm. The SiO band equivalent width (EQW) increases with spectral type. Water is clearly observed at M0III and it remains present at later spectra types (Heras et al. 2002). The silicon monoxide and water vapor features exhibit different behaviors with gravity: **the SiO lines become stronger with lower gravity** (positive luminosity effect), while **the H2O lines become weaker with lower gravity** (negative luminosity effect). The SiO fundamental band has been modeled by Aringer et al. (1997) but those models fail to reproduce the data presented here.



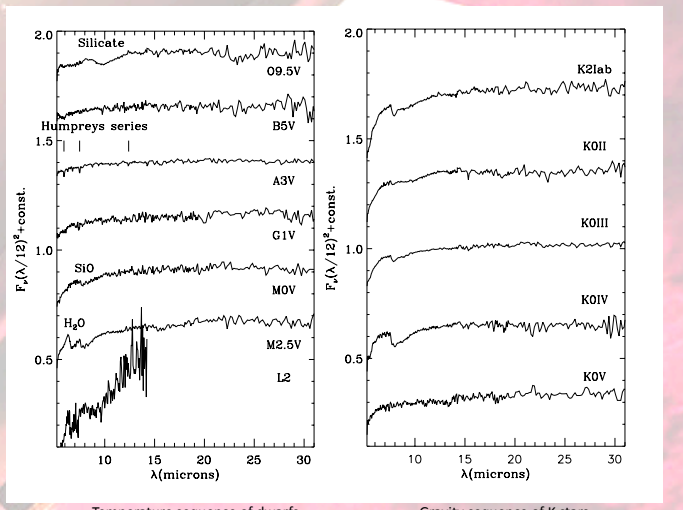

**Left**: Equivalent width of the SiO fundamental absorption. The two points not joined by a line are HD121146 (K0IV) and HD45829 (K2Iab).



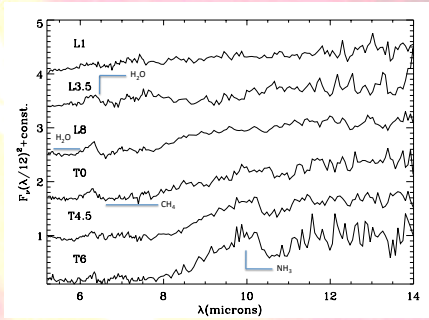

**Left:** The five M supergiant spectra available in the Atlas. No previous mid-IR spectroscopy is available in the literature for any of these targets. Two different groups:
(1) NGC 7419 #435 (M2Iab), NGC 7419 #139 (M3.5Iab), and BD+23 1138 (M5Ia) show weak PAH emission lines and broad emission bands at 7 and 12 μm.
(2) RSGC2 #2 (M3Iab) and RSGC2 #5 (M4Iab) present broad bands at 11 μm, 11.5 μm, and at 18 μm.

**Group (1)**: The morphology of sharp PAH features on top of broad plateaus, has been observed in the Orion bar by Bregman et al. (1989). A mixture of large (400 or more C atoms) and small (20 to 30 C atoms) PAH clusters is consistent with the observations. The appearance of PAHs in the spectrum may be due to excitation of highly processed PAHs on interstellar material by the stellar radiation field (Sloan et al. 2008).

**Group (2)**: While the broad 18 μm feature could be identified with silicate emission, the emission feature at 11 μm and/or 11.5 μm, is too red to be amorphous silicates. The SiC emission feature at 11 μm is a candidate, although the $C_2H_2$ feature at 13.7 μm, common in other carbon-rich objects, is not observed. For oxygen-rich stars, similar features are due to optically thin shells of alumina dust grains (see Egan et al. 2001). However, this is based on the analysis of AGBs, not supergiants. Sloan et al. (1998) conclude that supergiants generally produce dust shells composed of amorphous silicates. The true shape of the complex may also be confused by ISM silicate absorption at 10 μm.




Temperature sequence of dwarfs | Gravity sequence of K stars




**Left**:.L and T dwarfs. The Atlas includes L0 to T7.5 dwarfs (see Cushing et al. 2006).

**L and T dwarfs**: The water vapor bands at 5.8 μm and 6.75 μm result in an apparent emission feature at ~6.25 μm. Silicate clouds (Cushing et al. 2006; Stephens et al. 2009) are partially responsible for the broad absorption feature at ~9 μm observed in mid-L spectral types. The $\nu_4$ fundamental band of $CH_4$ at 7.65 μm appears in the latest L dwarfs and becomes stronger through the T sequence, and the combination of $H_2O$ and $CH_4$ absorption from 4 to 9 μm suppresses the flux in the spectra of the T dwarfs. The $\nu_2$ fundamental band of $NH_3$ centered at ≈10.5 μm appears in the spectra of the early- to mid-type T dwarfs.

**References**:


- Ardila et al. 2010, ApJS, submitted;
- Aringer et al. 1997, A&A, 323, 202;
- Bregman et al. 1989, ApJ, 344, 791;
- Cushing et al. 2006, ApJ, 648, 614;
- Egan et al. 2001, AJ, 122, 1844;
- Heras et al. 2002, A&A, 394, 539;
- Sloan et al. 1998, ApJS, 119, 141;
- Sloan et al. 2008, ApJ, 686, 1056;
- Stephens et al. 2009, ApJ, 702, 154;


The Atlas is available from:
(1) IRSA: **irsa.ipac.caltech.edu/data/SPITZER/SASS/**
(2) D. Ardila's webpage: **web.ipac.caltech.edu/staff/ardila/Atlas/index.html**
(3) Vizier: Within six months