

Near Infrared Spectroscopy of SAGE Sources in the LMC

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Introduction: We have completed an initial followup program to obtain *K*-band spectra of bright SAGE (Surveying the elements of a Galaxy's Evolution) sources [1]. The sources were selected from the *Spitzer* Cycle 3 IRS program, SAGE IRS. Thus our ~40 sources have near infrared and mid infrared spectra which can be used to fully characterize their nature and physical properties.

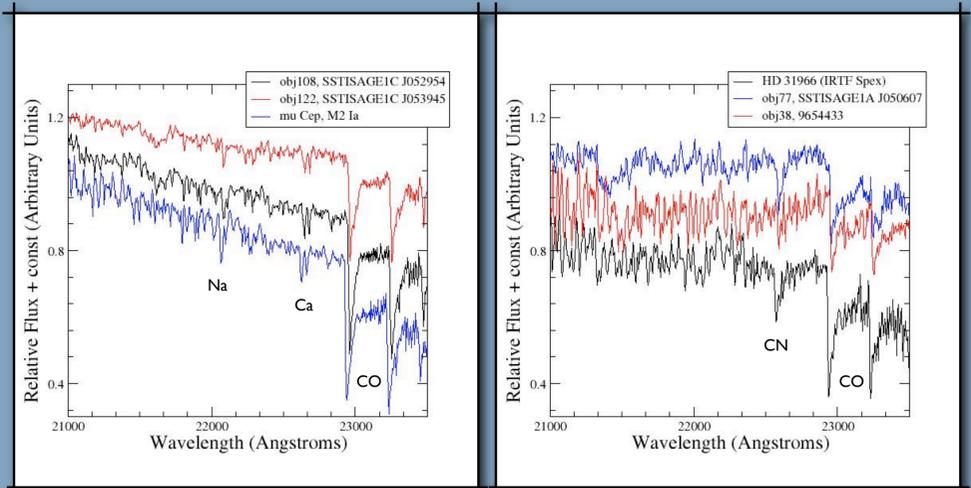


Figure 2: "Visible" O-rich (left) and C-rich (right) spectra from the observed sample (see Figure 1 and [2]). Comparison stars are from the IRTF spectral atlas at similar resolution [5]. Several strong features are indicated. The LMC spectra are slightly redshifted compared to the Galactic standard stars.

Results:

- The NIR spectra exhibit features which correlate well with the object type from the SAGE catalog [2] for evolved stars ($J-[8] < 4.1$ in Figure 1); see Figure 2.
- Extreme AGB stars [2] appear to show weak CO and CN (Figures 2,3) suggesting they are C-rich and there is a natural evolution off the optically visible C-rich branch of the CMD onto the Extreme or dust enshrouded branch (Figure 3).
- None of the seven SOAR YSO candidates showed features of young massive stars, though the full IRS sample does confirm other YSO candidates [6].

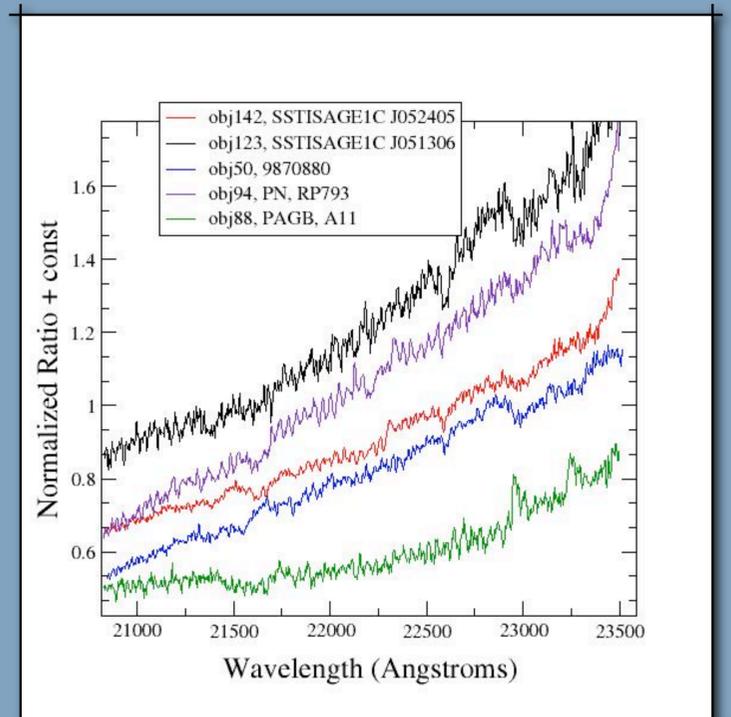


Figure 3: "Obscured" or Extreme AGB spectra (see Figure 1 and [2]) from the observed sample. Molecular features are seen in the spectra which indicate these are dusty C-rich stars. CO at 22935 Å is present, as well as CN at 22580 Å. The post AGB star, A11, exhibits CO emission.

References:

- [1] Meixner, M, et al. 2006, AJ, 132, 2268
- [2] Blum, R. D., et al. 2006, AJ, 132, 2034
- [3] Whitney, B., et al. 2008, AJ, 136, 18
- [4] Hora, J., et al. 2008, AJ, 135, 726
- [5] Cushing M. C., et al. 2005, ApJ, 623, 1115 and <http://irtfweb.ifa.hawaii.edu/~spex/WebLibrary/>
- [6] Marckwick-Kemper, F, et al. 2008, These proceedings

The authors wish to acknowledge useful conversations with Ken Hinkle regarding line identifications.

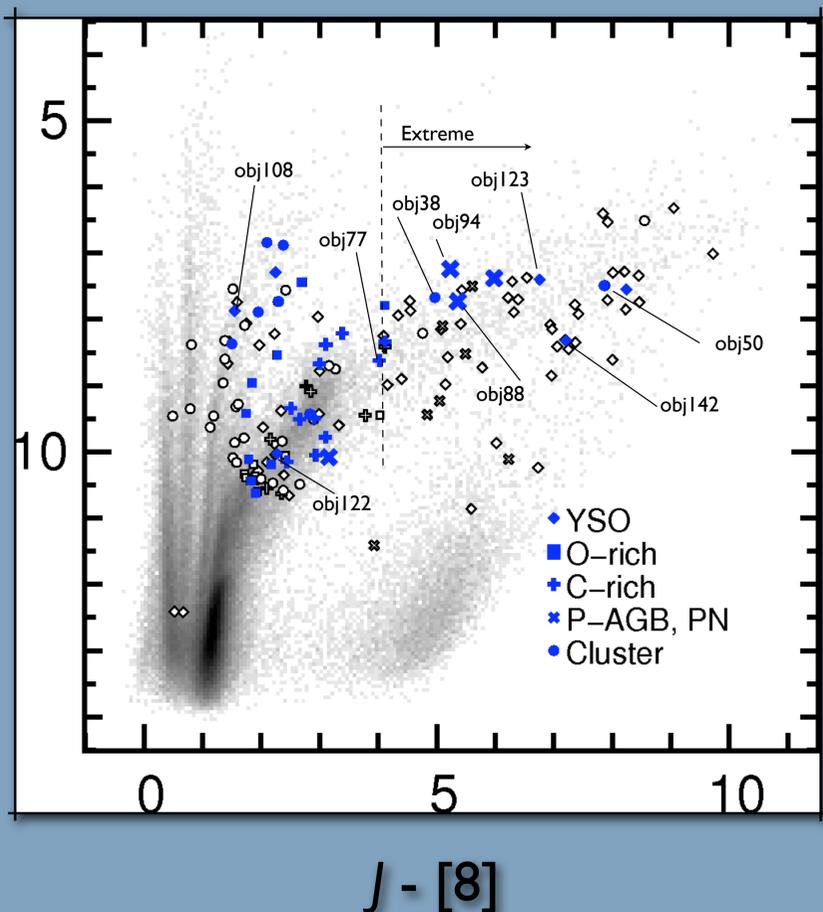


Figure 1: SAGE IRS point source targets over-plotted on the $J-[8]$ vs $[8]$ color magnitude diagram (CMD, shown as Hess diagram). The SAGE IRS sample is shown in open symbols and the objects actually observed at SOAR in the *K*-band are shown in blue. The NIR spectra show all the C-rich, O-rich, cluster, and YSO candidates observed are evolved stars (see [3] for YSO selection criteria which overlap with evolved stars).

Sample and Observations: Our sample was chosen using the IRAC and MIPS 24 μ m data from the SAGE catalog (see [1] and Figure 1). Objects were identified for the *Spitzer* Cycle 3 SAGE IRS program and included O-rich (AGB and supergiant) and C-rich AGB stars, cluster members, extreme mass losing stars [2], YSOs [3], PNe [4], P-AGB stars, and "unknown" sources.

Spectra were obtained with OSIRIS on the SOAR 4.1-m telescope located at Cerro Pachón, Chile in November, 2007. Only stars with $K \sim /< 12$ were observed at SOAR.