The stellar populations in the Large Magellanic Cloud

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We present the classification results of SAGE-Spec, a Spitzer Legacy project which obtained IRS spectra of a number of point-source-like objects in the Large Magellanic Cloud (LMC; Kemper et al. 2010). Such a survey gives us information about the dust content of the LMC, and identifying the nature of the objects detected in the mid-IR helps us to understand how that dust is cycled. We detail the object classification process, and the results which can be drawn from such an endeavour. We can reliably distinguish red supergiants from oxygen-rich AGB stars by means of colour, and are able to trace the evolution of carbon-rich evolved-stars by means of their dust content. We also find that (massive) young stellar objects fall into one of four evolutionary groupings.

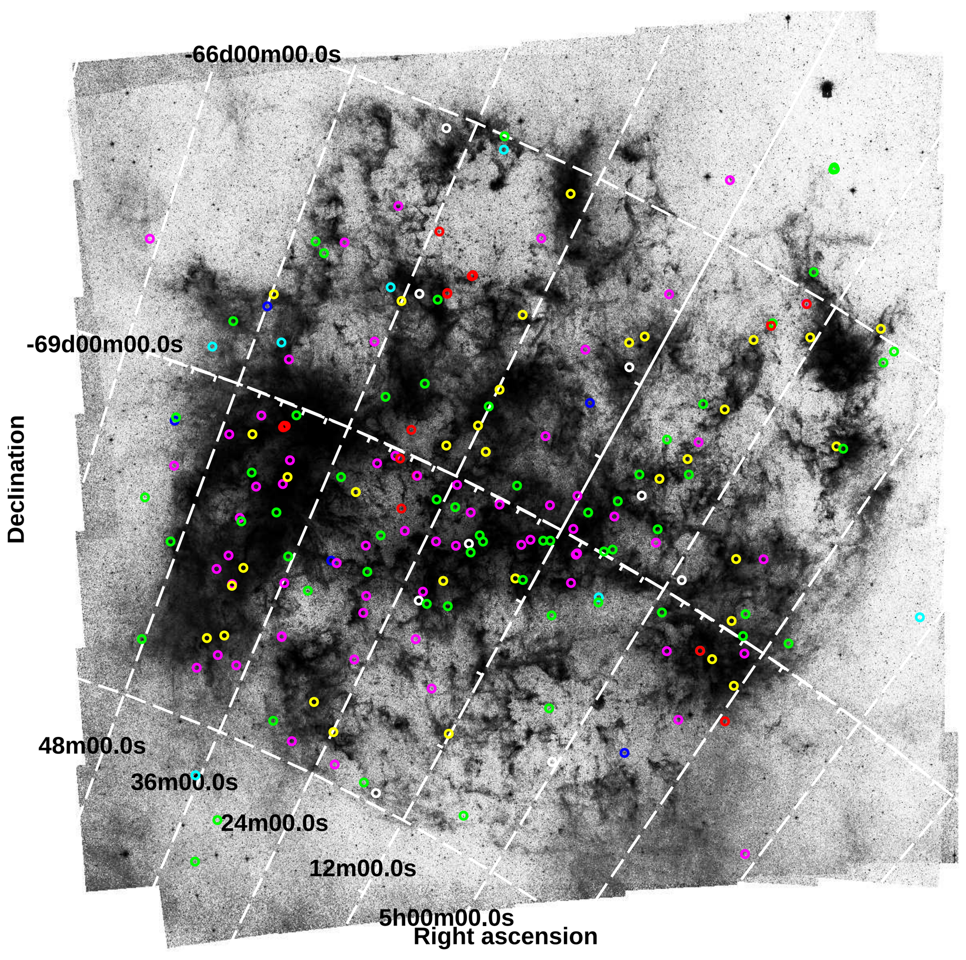
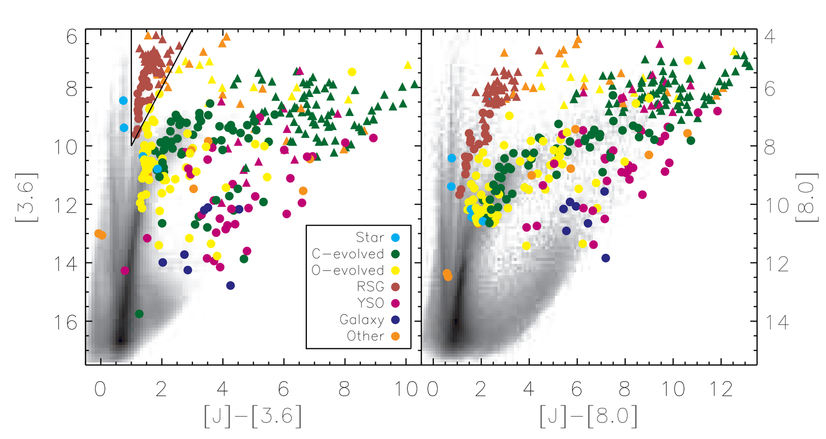


Table 1: Object type tally

C-AGB	53	OTHER	6
O-AGB	39	STAR	5
YSO	28	HII	5
RSG	19	C-PAGB	5
O-PAGB*	18	O-PN	5
(*inc. RV Tau)	(9)	C-PN	3
GAL	7	UNK	4

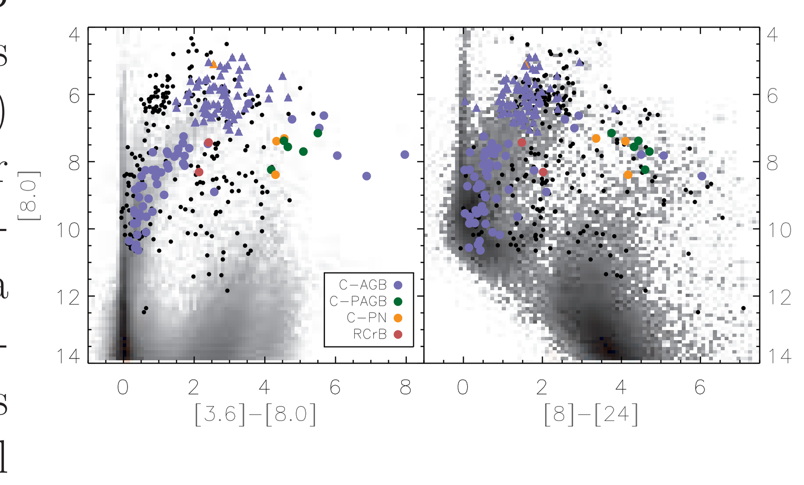
Classification

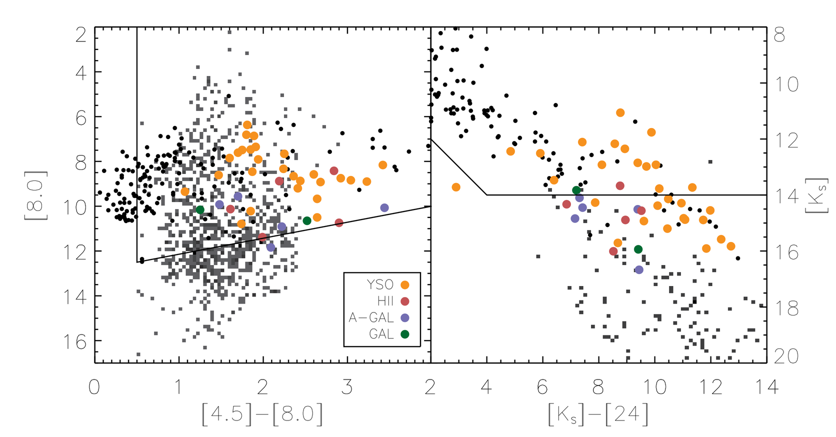
197 point sources were classified according to their Spitzer IRS spectra ($\lambda\sim$5.2-38 μm), associated UBVIJHK, IRAC and MIPS photometry, luminosity, variability, age and other information. For this a decision tree was constructed (Woods et al. 2010), which not only allows for a robust classification, but also can be adapted for use on other infrared data sets, e.g., from AKARI, JWST. Objects were classified into a number of groups: stellar photospheres, oxygen- and carbon-rich AGB stars, post-AGB stars and planetary nebulae, red supergiants, young stellar objects, galaxies, HII regions and "other" objects. A tally of the number in each group is presented to the right, and their positions plotted on a SAGE 8 μm image of the LMC. This sample is diverse and contains some interesting individual objects – a protoplanetary nebula which exhibits the first detected extragalactic 21 μm feature, a quasar with strong silicate features that is potentially host-less, a Wolf-Rayet star, two RCrB stars and a suite of extreme carbon stars (Kemper et al. 2010 and references therein).



The colour-magnitude diagram (left) shows the entire SAGE-Spec sample (circles), along with the sample of Kastner, Buchanan et al. (2006, 2008, 2009; triangles), who selected systematically brighter sources at 8 μm in the LMC. Red supergiants are fairly cleanly separated from O-rich AGB stars with a simple cut. The greyscale Hess diagram in the background shows the number density of point sources from the SAGE survey.

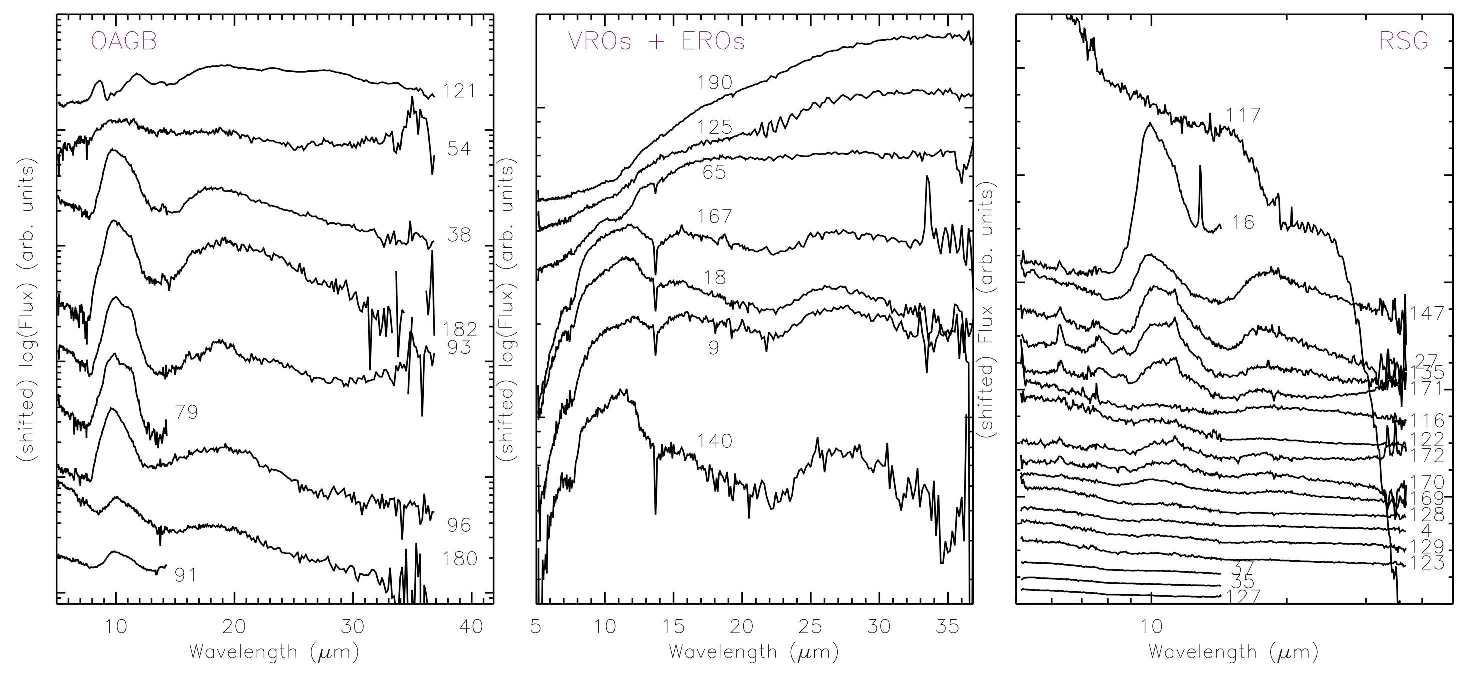
In the CMD (right), the evolution of carbon-rich AGB and post-AGB objects can be seen. As these stars evolve from the AGB ([3.6]-[8.0]$\sim$1) they become progressively redder in [3.6]-[8.0] colour, and in (spectral) appearance – see the spectra in the Discussion box. In this representation, the extreme carbon stars (EROs and VROs) are co-spatial with the C-rich post-AGB objects.



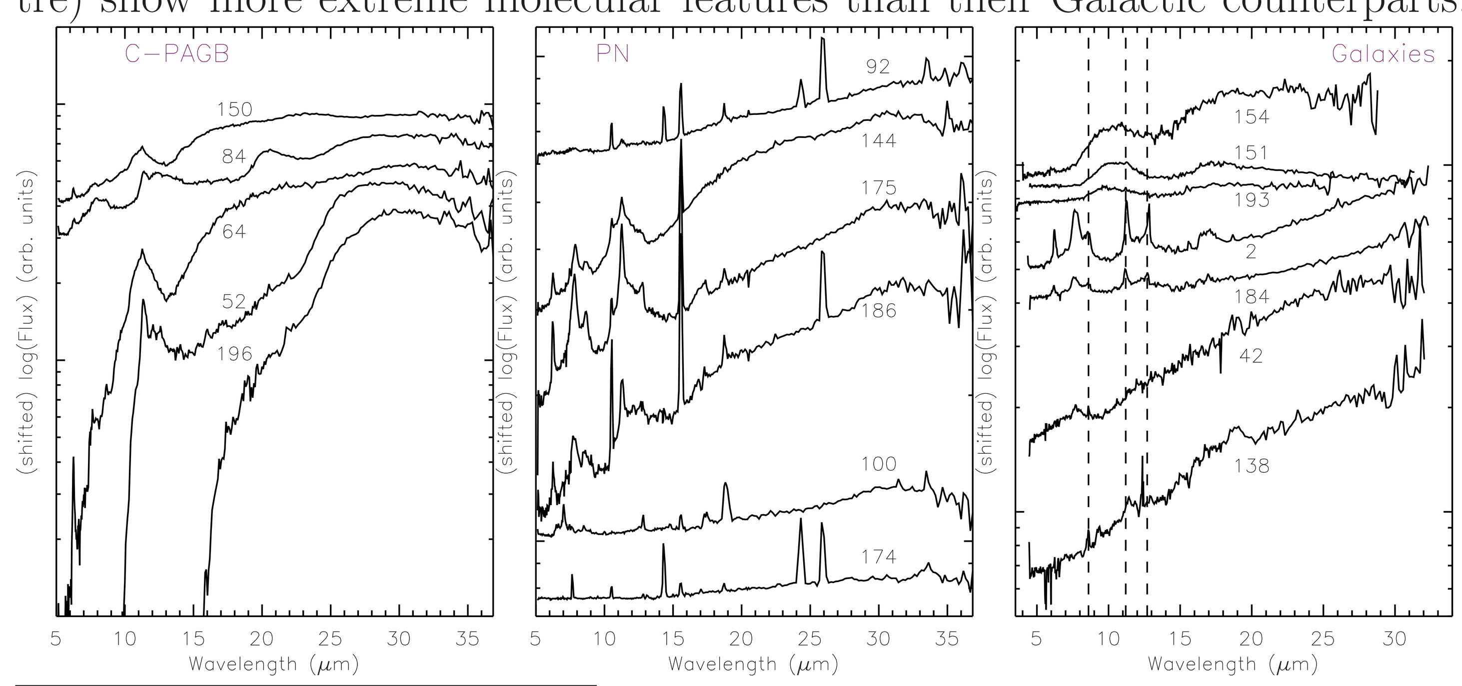


YSO spectra can be separated into four groups according to features, which correspond to the traditional classes. In colour-magnitude space, cuts used to separate galactic YSOs from background galaxies (Kirk et al. 2009 shown here) are not as effective for the SAGE-Spec sample.

Discussion



The SAGE-Spec dataset, which by nature of its Legacy Project status has been made public[a], is an excellent source for the study of a galaxy as a whole. Its scientific value is many-fold. Spectral classification of these 197 objects, which will be closely followed by the classification of another $\sim$600 objects in the Spitzer IRS archive, will allow us to verify the larger photometric classifications that have come out of recent studies of the LMC. The SAGE survey (Meixner et al. 2006), for example, detected 6.5 million point sources in the LMC with IRAC and MIPS. By relating the spectral identification of objects to regions in colour-magnitude space, a grand picture of the stellar populations of the LMC can be obtained rapidly. Moreover, since spectral features provide information on dust composition, we can investigate the physical and chemical environments in the LMC. It is well-known that the LMC has a sub-Galactic metallicity, and presumably this affects the gas-to-dust ratio in the LMC, particularly for silicate dust. Only a few of the 39 O-rich AGB stars detected are significantly dusty (see upper figure, left). A number of extremely- and very-red objects (EROs, VROs) were also discovered in this sample, and these dusty carbon stars (see upper figure, centre) show more extreme molecular features than their Galactic counterparts.



[a] http://ssc.spitzer.caltech.edu/spitzermission/observingprograms/legacy/sagespec/

References

- Kemper et al. (2010), arXiv, 1004.1142
- Meixner et al. 2006, AJ, 132, 2268
- Buchanan et al. (2009), AJ, 138, 1597
- Kirk et al. (2009), ApJS, 185, 198
- Woods et al. (2010), in prep.

Background image of the LMC credit: M. Meixner, K. D. Gordon (STScI) & the SAGE team.
This poster was produced using LaTeX; thanks to Dave Jones for championing such a frustrating software solution.