Searching for IR Excesses around Li-Rich and Rapidly Rotating K Giants Using WISE

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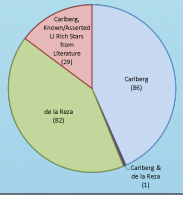
ABSTRACT & BACKGROUND: Stars evolving from the main-sequence (MS) to the red giant branch (RGB) exhibit several characteristic changes, including expansion and cooling of the outer layers, decrease in rotation rate, and a series of new shell-burning and core-burning phases. A number of RGB K giants exhibit uncharacteristically rapid rotation rates that seem to correlate with high lithium abundances (A(Li)) (Carlberg et al. 2012). These higher rotation rates and A(Li) are inconsistent with those predicted by standard stellar evolutionary models. Previous studies have suggested that many of these high Li RGB stars have IRAS excesses suggestive of a circumstellar shell or disk (de la Reza et al. 1997, Drake et al. 2002). Proposed hypotheses to explain these characteristics include accretion of giant planets or a newly triggered fusion stage causing ejection of a dusty shell. Using data from the Wide-field Infrared Survey Explorer (WISE), which has a higher spatial resolution than IRAS, we have reevaluated these IRAS-selected targets and added additional RGB K giants from Carlberg et al. (2012) that were selected without regard to IR brightness. Our findings indicate that many of the IRAS sources that exhibited an IR excess were non-stellar objects, clusters of stars or galaxies, or otherwise not RGB stars, casting doubt on the correlations found previously. Very few of the Carlberg et al. sample have IR excesses, making it difficult to assess if there is a correlation in this sample. Our companion poster, Deeb et al. presents the educational aspects of this project. This research was made possible through the NASA/IPAC Teacher Archive Research Program (NITARP) and was funded by NASA Astrophysics Data Program.

Source Selection

Origins for the 196 sources.

- 82 sources from de la Reza et al. (1997), originally selected from IRAS catalog.
- 86 sources from Carlberg et al. (2012), selected without a bias toward infrared brightness.
- (1 source selected by both de la Reza et al. (1997) and Carlberg et al. (2012).)
- 29 additional possible Li-rich giants compiled from the literature by J. Carlberg.



METHODS

- Collect source lists primarily from de la Reza et al. (1997) and Carlberg et al. (2012) lists of K giant candidates, add literature sources.
- Examine sources individually through imaging provided by Finder Chart, including a visual analysis of differences between SDSS, WISE, 2MASS, and IRAS. Begin to make preliminary classifications for candidates that exhibit non-point source characteristics or source confusion between various point sources, as well as identification of any saturation issues from telescopes.
- Create and analyze SEDs for each source. Examine SEDs for non-stellar characteristics, possible infrared (IR) excesses, and differences in brightness between WISE and IRAS.
- Create color-magnitude diagrams and color-color diagrams to identify non-stellar sources and note remaining sources that exhibit an IR excess.
- Analyze K_s-[22] and the [3.4]-[22] bands to look for IR excess. The IR excesses were determined by comparing the expected K_s-[22] and [3.4]-[22] to the observed value, including error margins, as follows (for [3.4]-[22]):

$$\chi_{22} = \frac{([3.4]-[22])_{observed} - ([3.4]-[22])_{predicted}}{\sigma([3.4]-[22])}$$

- Look for correlations between lithium abundance A(Li), rotation rate, and a significant IR excess.

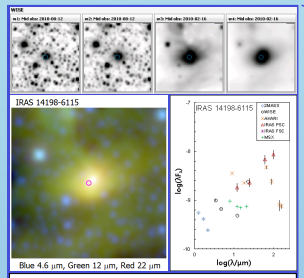
RESULTS

- Because IRAS is less sensitive than WISE, the de la Reza (1997) sources (selected from IRAS catalogs) are biased towards bright IR detections. With newer evidence provided by the higher spatial resolution of WISE, **many of these sources are likely not K giant stars**, and demonstrate markedly varied SEDs and imaging (see examples including IRAS16128-5109 on this poster and in Sun et al. 2014).
- Only 127 of the original 196 sources look okay in images and have relatively clean SEDs (not obviously non-stellar SEDs) from which we can assess IR excesses. (only ~30% of the de la Reza sources survive this check.)
- Only 2 of the 196 sources have measured χ ([3.4]-[22])>3; they are both from the much less biased Carlberg sample (G0928+73.2600 & Tyc0276-00327-1). Both of them appear to have a very small IR excess (<0.7mag).
- Up to 27 of the original 196 sources may have χ (K_s -[22])>3, but most of those have suspicious K_s or [22] (or too-small errors).
- Due to the small sample of star candidates with IR excesses, correlations between A(Li) and rotation rate are difficult to determine.
- Most of the original de la Reza sources are not likely K giants or do not likely have excesses. **Our findings place some doubt on prior correlations found between IR excess and A(Li),** as demonstrated by de la Reza (1997) and Siess & Livio (1999).

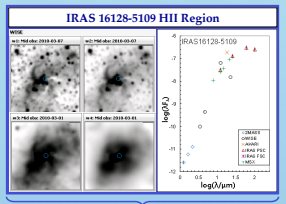
Please visit the companion poster

Deeb, et al. : Measuring The Effectiveness of an Authentic Research Experience in Secondary Astronomy Education Through Concept Mapping.

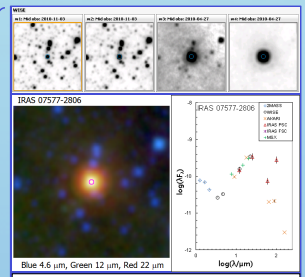
Inspection of IRAS sources with WISE revealed several non-stellar sources



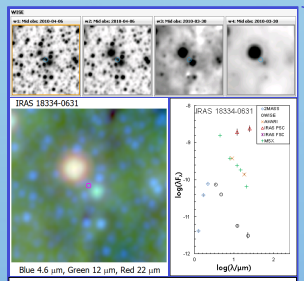
IRAS 14198-6115 Example of Source Confusion



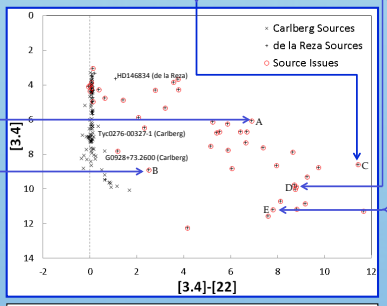
IRAS 16128-5109 HII Region



IRAS 07577-2806 Post AGB Candidate

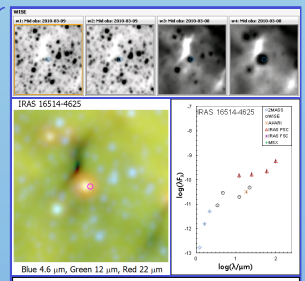


IRAS 18334-0631 Example of Source Confusion



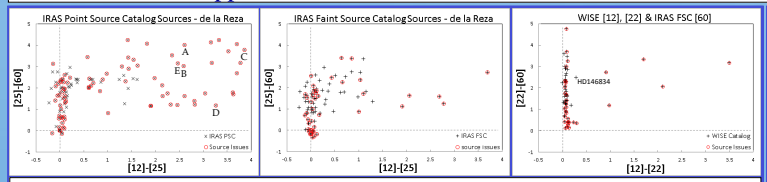
Observations

Many IRAS sources that exhibited an IR excess were found to be objects other than RGB stars after inspection with WISE.



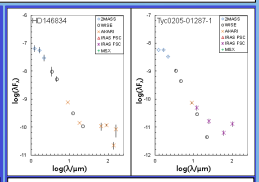
IRAS 16514-4625 IR Source

Sources that appear to have an infrared excess in IRAS do not exhibit this excess in WISE



LEFT/CENTER: These two IRAS color-color diagrams closely match the [60-25] vs. [25-15] diagram used by de la Reza et al. (1997), as part of a model relating Li abundance to IR excess in K giant stars, where $[\lambda_1 - \lambda_2] = \log\ \lambda_2 S_{\lambda 1} - \log\ \lambda_1 S_{\lambda 2}$, and S_λ is the IRAS flux density. The sources with the greatest IR excesses in both the IRAS Point Source Catalog and the IRAS Faint Source Catalog are very likely not RGB stars (e.g., clusters of stars or galaxies). RIGHT: A similar color-color diagram using WISE 12 μm and 22 μm with IRAS FSC 60 μm shows that the overall size of the IR excess decreases significantly. Only one of the remaining sources (HD146834) is a likely RGB star with an IR excess.

Key for IRAS PSC color-color diagram match to source images above, A:IRAS14198-6115, B:IRAS16128-5109, C:IRAS16514-4625, D:IRAS18334-063, and E:IRAS07577-2806



The SED on the left shows the apparent IR excess of HD146843 from K_s to [22]. The SED on the right is representative of stellar sources that appear to exhibit infrared excess with IRAS, but do not exhibit this excess to 22 μm with the higher spatial resolution WISE data.