CRIRES Science Verification Proposal

Astro-chemistry in dust formation regions

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Abstract:

This is a re-submission of a previous granted CRIRES SV pilot study. We propose a CRIRES wavelength scan from 2.1–5μm at maximum resolving power in the dust forming region of the red supergiant VY CMa and the famous AGB star IRC+10216. The supergiant is one of the strongest IR source of the sky. The vicinity of IRC+10216 makes it to the best studied AGB star. Both objects have extraordinary high mass loss rate. At the CRIRES sensitivity the spectra will provide a manifold of spectrally and spatially resolved lines. Discovery of so far undetected lines is predicted using laboratory data. VY CMa is also interesting technically as its high brightness is used to search for spurious reflections in the combined instrument and telescope system.

Scientific Case:

VY CMa and IRC+10216 are stars with prodigious mass-loss rates of $\dot{M} \sim 100$/year, respectively. As a consequence, they have dense, dusty envelopes. The extremely carbon-rich IRC+10216 has a very rich molecular spectrum at millimeter wavelengths which is easy to observe due to the vicinity of the star (D $<$ 150 pc). The peculiar red supergiant VY CMa is amongst the strongest infrared sources in the sky.

So far high resolution observations of VY CMa and IRC+10216 are only available in the millimeter where a very rich molecular spectrum is detected. The submm observations probe the outer envelopes, whose molecular composition consists of species that survive dust formation and whose relative abundances become modified by the ionizing and dissociating radiation of the ambient interstellar radiation field.

NIR spectroscopy, in contrast, probes regions between the stellar photosphere out to and within the dust formation region. It allows observations of the parent molecules that form in thermochemical equilibrium near the photosphere and whose abundances "freeze out" during the dramatic density drop of dust formation and/or which are depleted into dust grains. The ISO Short Wavelength Spectrometer spectra are extremely rich although not yet published as a whole because of blending. In particular, Harwit (2002, NASA Laboratory Astrophysics Workshop, NASA/CP-2002-21186) notes "A spectrum of VY CMa found in the archives of ISO exhibits many hundreds of unresolved lines between 2.5 and 45 mm, most of which are unidentified".

The high spectral resolution afforded by CRIRES is crucial to understand the dynamics of this complex spectral region for several regions. It will provide (1) information on the velocity field in these complex envelopes, in particular by (2) resolving lines, many of which are expected to exhibit P Cyg profiles or even inverse P Cyg profiles in their absorption and emission portions. (Such profiles are indeed seen in spectra taken with the KPNO FTS system; K. Hinkle pers. comm.). (3) Line confusion which hampered the analysis so far can now be overcome with the high resolution of CRIRES. Perhaps most interestingly, (4) species not previously identified in stars might be found as suggested by molecular spectra in the lab. Therefore the requested spectrum will provide a lot of new insights in the chemistry of the dust formation process.

Required observing time

Observing time for this project was granted at the previous CRIRES SV call. We have already asked for observing time on IRC+10216 in August however at the time the object was, as mentioned, not visible. VY CMA could not be executed in October by similar scheduling reason. For this period both objects are "up" and most of the night at low airmass.

VY CMA is one of the brightest IR sources in the sky. This observation of an extreme IR bright target will also be used as commissioning test for searching of spurious reflections such as ghosts or other artifacts of the combined instrument and telescope system. Further it will establish the acquisition task on extreme bright IR objects.

The high brightness of the targets allow to use the maximum resolving power of CRIRES, the 0.2" slit. Targets will be used as AO reference star. Atmospheric stability in the thermal NIR requires to alternate between nodding AB positions in less than 5min. We will apply one nodding cycle (AB). At given brightness DIT=1s is needed and NDIT=10 setting will ensure SNR of a few hundred as computed with present ETC. A wavelength scan in the requested K, L, M band (2100–5000nm) needs about 1h as estimated from our successful L,M CRIRES scan on W33A performed in Oct. Same observing time is required for the telluric standard.

Therefore we ask again for a total of **4h** for this study.

Target	**RA**	**DEC**	**Wavelength Band**	**Magnitude**	**DIT**	**NDIT**
VY CMa	07 22 58.3	-25 46 03	2100-5000	K=0.2	1s	10
IRC+10216[c]	09 47 57.4	+13 16 44	2100-5349	K= 0.2	1s	10

[c]UT date 2007 Feb 1, around mid night proximity to Saturn $\sim 2.7^o$