CRIRES Science Verification Proposal

Road-map of astro–chemistry during massive star formation.

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Abstract:

We propose a CRIRES wavelength scan from 3664–5349nm on two extreme red and bright massive protostars: CRL2136 and W33A. At the CRIRES sensitivity such spectra will show a manifold of spectrally and spatially resolved lines. Discovery of so far undetected lines is predicted using data of the Cologne Laboratory for Molecular Spectroscopy. The spectra will provide a first road-map of astro–chemistry during the formation process of massive stars. Beside the interesting science both targets are very well suited to test our new acquisition template for CommIII on extreme red objects and our capability to merge interleaved wavelength scans into a single spectrum.

Scientific Case:

One of the first observational studies that used the word "protostar" was the seminal paper by Willner et al. (1982, ApJ, 273, 174). These authors defined protostars as "...infrared sources, having roughly blackbody energy distributions from 2 to 20 micron with color temperatures of 400 to 600 K ... These sources are distinct from compact HII regions ... Both types of sources are associated with molecular clouds ... ".

In their paper Willner et al. present and discuss low resolution (R=60) 2 to 13 micron spectra identifying the conspicuous solid-state (ice) bands from 2.8 to 3.5 and at 6.0 and 6.8 microns plus the silicate band at 9.7 microns. Their sample consists of sources with more more than a few times 10^4 solar luminosities. This paper triggered an immense amount of work in this area, culminating with the recent large number of ISO studies.

Higher resolution spectra revealed fine structure in the ice bands and comparison with laboratory templates led to the identification of ices from the H_2O, CH_3OH, H_2CO and other molecules (one feature was even ascribed to urea). ISO LWS spectra evaluated by the Leiden group also retrieved gas phase (narrow line) spectra in particular of H_2O, Co_2, and So_2. Moreover, (sub)millimeter observations show that the objects in questions have large scale envelopes containing a plethora of complex molecules at highly elevated abundances (compared to cold dark cloud values), suggesting that the icy dust gain mantles are evaporated by the newly ignited protostars.

The ISO LWS spectra had a relatively low resolution of R $\sim$ 2000. This may have led to spectral dilution making lines from rarer species undetectable. The combination of much superior spectral and spatial resolution afforded by CRIRES, well matched to the expected line widths (a few km/s), and its great sensitivity will result in a unique dataset that will open up a whole new field of molecular astronomy - gas phase NIR spectroscopy of organic species in star-forming regions. This is demonstrated by the R=33,000 high resolution UKIRT spectrum on one of our proposed targets: W33A. The spectrum covered only a very narrow range between 3.59 to 3.64μm but already provided the first discovery by detecting of gaseous formaldehyde (Roueff et al, 2006, A&A 447, 963). In this context we can state that our proposed SV CRIRES observations will provide a road-map of astro–chemistry during the formation process of massive stars.

We choose two sources: CRL 2136 from the pioneering work by Willner et al. and W 33A, which is a massive protostar of similar high brightness. ISO H_2O and Co_2 data (impossible to get from the ground) have been published for both sources. The CRIRES wavelength coverage will include vibrational bands of very many species. Together with the Cologne Laboratory for Molecular Spectroscopy, we are currently compiling line catalogs (which already exist for some interesting species, in particular CH_3OH) and will certainly be able to extract many interesting results and discover a manifold of so far undetected lines.

Required observing time

Both objects are extremely red, a few Jy in L,M but less than 16mag in K and too faint to close AO. Therefore they are very well suited to test the new design of the acquisition template of Com III. If not visible in the slit viewer image we offset blind from reference star and use AO star $\sim 10''$ away from the target having R=14mag. We use the 0.4" slit.

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=5sec, NDIT=7 will ensure SNR$\sim$50 as computed with the present ETC. A wavelength scan in the requested L, M band requires 36 settings. The total observing time including all overheads for one target is 60min. The high brightness of the science targets require same observing time for the telluric standard.

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

Target	**RA (J2000)**	**DEC**	**Wavelength Band**	**Magnitude**	**DIT**	**NDIT**
CRL 2136	18 22 26.5	-13 30 12	3664-5349	$>$ 1Jy	5	7
W 33A	18 14 39.0	-17 52 03	3664-5349	$>$ 1Jy	5	7

IRS1 position of CRL2136 (Kastner et al. 1992)

Flux as by our ISOSWS spectrum.