CRIRES Science Verification Proposal

Title: Probing the gas in the inner 50 AU of proto-planetary disks

Investigators	Institute	EMAIL
PI A.Carmona & D.Fedele	ESO, MPIA	carmona@mpia.de dfedele@eso.org
M.E. van den Ancker	ESO	mvandena@eso.org
Th. Henning	MPIA	henning@mpia.de
M. Goto	MPIA	goto@mpia.de
M. Wittkowski	ESO	wittkowski@eso.org
H. Linz	MPIA	linz@mpia.de
B. Stecklum	Tautenburg	stecklum@tls-tautenburg.de

Abstract:

This proposal is the result of merging the CRIRES SV proposals of A.Carmona et al. and D.Fedele et al. for the CRIRES SV august run (3h allocated).

We propose to search for H_2 emission at 2.1218 & 2.2214 and CO fundamental emission band at 4.7 micron in two well known stars surrounded by protoplanetary disks: LkHa 264 and 49 Cet. LkHa 264 is one of the few PMS stars with disks where H_2 emission at 2.1218 & 2.2214 micron has been detected. 49 Cet is one of the closest (70 pc) transitional objects known (7 Myr) with reported detections of CO in the submm (Dent et al. 2005) and H_2 emission at 17 and 28 micron by ISO (Thi et al. 2001). Our scientific objective is to constrain the dynamics, temperature and mass of warm and hot molecular gas ($150 < T < 1000$ K) in the inner 50 AU of the disk.

Scientific Case:

Despite the burst of exo-planets discoveries in the last years, still little is know about the physical conditions of the region where the planets form. Planets are thought to form in the inner region (R<50 AU) of circumstellar disks around pre-main-sequence stars. Mainly due to the lack of spatial resolution of present instrumentation, the exploration of planet forming region (PFR) is a challenge. One way to overcome this limitation is high resolution near-infrared molecular spectroscopy. The warm temperatures ($T > 150K$) and high densities ($n = 10^9 - 10^{15}$cm^{-3}) characteristic of the disk's inner region are able to excite a rich near-infrared spectrum of molecular ro-vibrational transitions (Najita et al. 2003). As a consequence, near-IR molecular spectroscopy is well suited to probe of the conditions (column density, temperature, dynamics) of the disk's PFR.

The study of planet-forming disks around young stars was one of the primary science drivers for the CRIRES instrument. It is important for the acceptance of this new instrument by the community that it produces some results with high visibility within the science verification phase. Our proposal has been designed with an optimal return in terms of guaranteed results in mind. We propose to observe two remarkable sources which have evidence of presence of gaseous disks: LkH_α 264 and 49 Cet. LkH_α 264 is one of few objects where H_2 emission at 2.1218 & 2.2214 micron has been detected (Itoh et al.2003). 49 Cet is one of the closest (70 pc) transitional objects known (7 Myr). It has reported detections of CO in the submm (Dent et al. 2005) and H_2 emission at 17 and 28 micron by ISO (Thi et al. 2001).

We propose to observe H_2 and CO in 49 Cet and H_2 in LkH_α (too faint in the M band for obtaining CO data in the 3h allocated). H_2 is the most abundant gas-phase molecule. To determine the excitation mechanism (thermal vs UV pumping) measurements of two lines are needed. The H_2 2.12 and 2.22 micron emission would give us constrains on the hot gas ($T > 1000$K) in the inner part of the disk. CO is the second most abundant molecule and the gas molecule with the largest Einstein coefficient. The measurement of the fundamental band at 4.7 microns will constrain the temperature and column density in the warm gas ($T > 150$K). For the bright object 49 Cet, the combination of H_2 and CO data will give us a handle on the chemistry of the disk.

With these data we would be able to:
1) explore the molecular gas within 50AU from the stars, which is little understood to date, but has direct consequences for planet formation.
2) reveal the disk kinematics at the inner edge of the gas disk. With the high spectral and spatial resolution of CRIRES, the assumption of Keplerian rotation of matter in the disk can be tested directly. One exciting possibility is that this method may directly reveal the presence of gaps in the radial distribution of matter in the disk, thereby providing indirect evidence for the presence of planets.
3) In 49 Cet by comparing the observations in CO and H_2 with different tracers (e.g. ionized gas/dust grains) we can attempt to understand the chemistry in the disks during its evolution.

The observations proposed here are particularly suited for being executed during the SV phase, since they consist of spectroscopy of relatively bright yet scientifically interesting sources. Photon noise will be a minor source of error in our data set. The final error in our data will be dominated by systematics (correction for telluric absorption). We expect these data to demonstrate the maximum achievable S/N with CRIRES. We believe our team and our proposal are optimally positioned to achieve this goal. Our group contains experts in infrared spectroscopy (Carmona, Goto, van den Ancker). Our team has also access to state of the art disk models to interpret the observations.

Required observing time

Three (3) hours have been allocated to this program in CRIRES-SV august run.
We request 3.3h for science observations and 2h for calibration observations.

Time Justification
The faintest reported CO line flux is 3.3e-15 erg/s/cm2 (Brittain et al. 2003, R(0) 4657.8 nm). The typical width of the lines is about 20 km/s (NISRPEC, Blake & Boogert 2004). The faintest H_2 line flux reported at 2.12 micron is of 1e-15 ergs/s/cm2 (Bary et al. 2003). Therefore, our goal is to be sensitive line fluxes of the level 1e-15 erg/s/cm2.

According to the exposure time calculator for attaining this flux level 5 min are required for the H_2 line at 2.12 micron, and 6 min for the CO lines at 4.7 micron. However, to be able to disentangle this faint flux a signal to noise larger than 30 is required in the continuum.

For the H_2 observations we require an exposure time of 20x30s=10min for LkH_α 264 (K=8.9 mag) and 10x30s=5min for 49 Cet (K=5.5 mag) in each grating . We observe 2 gratings, therefore, 2x10min=20min are required for LkH_α 264 and 2x5min=10min are needed for 49 Cet.

For the CO observation in 49 Cet (M=5.5 mag) we require an exposure time of 40x30s=20min in each grating. We observe 4 gratings, therefore, 4x20min=80min are required.

For the exposure time calculation we employed a seeing of 0.8, an airmass of 1.1, and a slit width of 0.4".

The total overhead time (AO and target acquisition, nodding cycle, grating change, wave calibration) is $\sim$65 min for the 49 Cet observation and $\sim$ 25min for LkH_α 264 observation.

The total amount of telescope time required for completing our program is 20+25+10+80+65=200min=3.3h Two (2) additional hours are required for observing STD stars immediately following or preceding the target observation.

Note: Observations of one backup Herbig Ae star are proposed in case an extra object is required at RA 20° (HD190073).

Target	RA	DEC	Wavelength Band	Magnitude	DIT	NDIT
PRIORITY:				(J,H,K,M)		
LkH$_\alpha$264	02 56 37.51	+20 05 37.1	27/1/n	(10.2, 9.4, 8.9, 7.7)		
			2087 - 2133 nm	F$_{line}$=1e-15/erg/s/cm2	30s	20
			25/-1/n			
			2200 - 2255		30s	20
49 Cet	01 34 37.78	-15 40 34.9	27/1/n	(5.4, 5.5, 5.5, 5.5)		
			2087 - 2133 nm	F$_{line}$=1e-15/erg/s/cm2	30s	5
			25/-1/n			
			2200 - 2255		30s	5
			12/-2/i			
			4499 - 4620		30s	40
			12/-1/i			
			4602 - 4715		30s	40
			12/1/i			
			4705 - 4809		30s	40
			11/-2/n			
			4840 - 4977		30s	40
BACKUP						
HD 190073	20 03 02.50	+05 44 16.6	27/1/n	(7.2, 6.6, 5.9, 4.2)		
			2087 - 2133 nm	F$_{line}$=1e-15/erg/s/cm2	10s	5
			25/-1/n			
			2200 - 2255		10s	5
			12/-1/n			
			4499 - 4620		30s	12
			12/-1/i			
			4602 - 4715		30s	12
			12/1/i			
			4705 - 4809		30s	12
			11/-2/n			
			4840 - 4977		30s	12