CRIRES Science Verification Proposal

The most massive stars in the Galactic Center: binarity and metallicity

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Abstract:

We propose observations of the very massive Pistol star in the Galactic Center in order to test its possible binary nature and to derive alpha elements and Iron abundances. The Pistol star is only accessible in the infrared due to the strong foreground extinction, and faint AO guide stars are found within 10-20". These observations are well suited for science verifications since they allow to test AO corrections with faint guide stars (R $\sim$ 15-16) and the science cases match the goals of CRIRES (physical properties - abundances, binarity, winds - of massive stars).

Scientific Case:

The center of the Galaxy harbours a large number of massive stars. They are mainly concentrated in three young clusters: the Quintuplet, the Arches and the central cluster. Among these stars, several are extremely luminous: the Pistol star in the Quintuplet region and the so-called 'IRS16' stars in the central cluster are the most famous ones. They are evolved massive stars close to the Humphreys-Davidson limit above which their atmospheres become unstable and experience strong mass ejections in a Luminous Blue Variable (LBV) phase. They are also thought to be among the most massive stars known. In particular, Figer et al. (1998) estimate a mass of nearly 200-250 Msun for the Pistol star. This, together with other evidences of a top-heavy IMF (Figer et al. 2002, Paumard et al. 2006), indicates that the Galactic Center tends to produce an excess of massive stars.

Here, we propose to observe one of these very massive stars with CRIRES: the Pistol star in the Quintuplet region. First, we would like to perform abundance determinations for alpha elements and Iron. This would help to constrain the metallicity of the Galactic Center. This quantity is still under debate, studies of red supergiants revealing a solar Iron content (Carr et al. 2000, Ramirez et al. 2000) while recent X-rays analysis favour a largely super-solar value (Z=4xZsun, Maeda et al. 2002). Moreover, metallicity gradients in the Galactic disks extrapolated to the Galactic Center indicate also super-solar values (Martin-Hernandez et al. 2003). A better knowldege of the global metal content of the GC is thus clearly needed, especially in the context of the chemical evolution of the Galaxy. Individual metal abundances are also highly required since they can trace top-heavy initial mass functions, alpha elements being preferentially produced in high mass stars while type Ia supernovae are the main contributors to the Fe production. The Pistol star is a perfect target for metallicity studies since it shows a number of weak FeII, SiII, MgII and NaI lines. These features need to be observed with large S/N ratio and spectral resolution to be subsequently analysed with atmosphere models in order to get both alpha elements and Fe abundances.

Second, we want to tackle the question of the possible binarity of this star. The very high luminosity of

the Pistol star makes it the most massive star known to date, but also a natural candidate for binarity. Resolving this issue of binarity is crucial in the context of a possible universal upper mass cut-off in the stellar initial mass function around 150 $M_{\odot}$ (Oey & Clarke 2005, Figer 2005). High spectral resolution CRIRES observation of the Pistol star should bring evidence for a possible companion.

These observations perfectly match the science cases of CRIRES: abundance studies plus, as a by product of our initial science goals, derivation of the stellar and wind properties through strong emission lines of massive stars. The Pistol star is not observable at shorter wavelengths due to the strong extinction. In addition, AO guide stars are faint and the proposed observations should then test the limit of CRIRES AO corrections.

References:
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Martins et al., 2005, A&A, 2005, 441, 735
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Oey & Clarke, 2005, ApJL, 620, 43
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Ramirez et al., 2000, 537, 205

Required observing time

Target	RA	DEC	Wavelength Band	Magnitude	DIT	NDIT
Pistol star	17 46 15.3	-28 50 04.2	1672-1713	K=7.5	100	5
			1713-1751		100	4
			2122-2175		100	7
			2200-2255		100	6

Exposure times estimated with the CRIRES-ETC version 3.1.3 with:

− slit width = 0.4"
− seeing = 0.8"
− airmass = 1.30

The observational constraint was to get a S/N of 80. We thus need 30 minutes on source.

reference star: UCAC2-19979301
RA: 17:46:15.754 (J2000)
DEC: -28:50:14.28 (J2000)
V 16 / R 15.0 (B-R=1.40)
distance: 10"

Important Note: Our programme was accepted for the first SV run but could not be observed due to problems with the finding charts and the AO system (loop not closed). In March, the target will be observable only in the last hour of the night.