X-shooter Science Verification Proposal

Line Emission Diagnostics to Probe a SNR

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Abstract:

An intriguing newly discovered object, selected based on IR-excess on Spitzer photometry, has been observed in the Serpens Molecular Cloud with the InfraRed Spectrograph (IRS) on board the Spitzer Space Telescope. The IRS spectrum presents strong high ionization lines consistent with a supernova remnant (SNR). Although these data give important clues, it is not possible to confirm the nature of this source by the IRS spectrum alone. Complimentary high resolution spectroscopy is necessary to disentangle this puzzle and rule out other interpretations such as a dusty planetary nebula. Bright spatially resolved emission lines in a wide range of wavelengths should provide the necessary information and confirm this object as a SNR. With X-shooter on the VLT, enough S/N for line detection can be achieved in 45 minutes. If confirmed, this object will be the 2nd SNR discovered by its infrared properties.

Scientific Case:

In a campaign designed to characterize the circumstellar disks of a sample of IR-excess young stellar objects (YSOs) in the Serpens Molecular Cloud with Spitzer/IRS, a very interesting object was discovered. The very bright, high ionization emission lines seen in this object (Figure 1) are not consistent with it being a YSO.

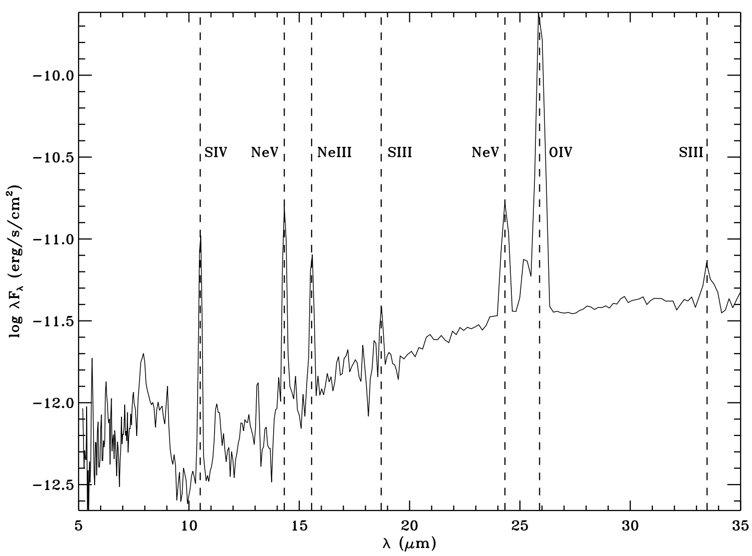

Figure 1: IRS spectrum at R = 50-100 of the possible supernova remnant found among our IR-excess sample.

Extensive searches in archives failed to provide any new information on this object: no detection on the Two Micron All Sky Survey (2MASS), on the Digitalized Sky Survey (DDS) nor on the ROSAT All Sky Survey. No observations were performed on the Chandra X-ray Observatory nor on the Canadian Galactic Plane Survey or XMM-Newton Observatory.

The IRS spectrum, as seen in Figure 1, is dominated by [O IV] (25.89 μm), but [S IV] (10.51 μm), [Ne V] (14.32, 24.32 μm), [Ne III] (15.56 μm), [S III] (18.71 μm, 33.48 μm) are also present. This matches very well with similar spectra in the literature of supernova remnants (Morris et al. 2006, Sandstrom et al. 2008, Ghavamian et al. 2009, Sandstrom et al. 2009). PAH features at 6.2, 7.7, 11.2 and 12.8 μm are also observed in this spectrum, being likely emitted by the hot gas around the object (Micelotta et al., submitted). However, the low spectral resolution ($\lambda/\Delta\lambda$ = 50-100) of the our IRS spectrum does not allow precise information on line width.

Complimentary imaging of Serpens in the R-band (INT/WFC) has shown a faint and extended object (Figure

2). This result is consistent with a SNR, reinforcing the suspicions. Still, for a confirmation that this object is indeed a not yet reported SNR, additional data are necessary. In particular, in the other plausible interpretation, a dusty planetary nebula, the lines should be much narrower ($\Delta V \sim$ few $\times 10$ kms^{-1}) than for a SNR ($\Delta V \sim 10^2$–10^3 kms^{-1}).

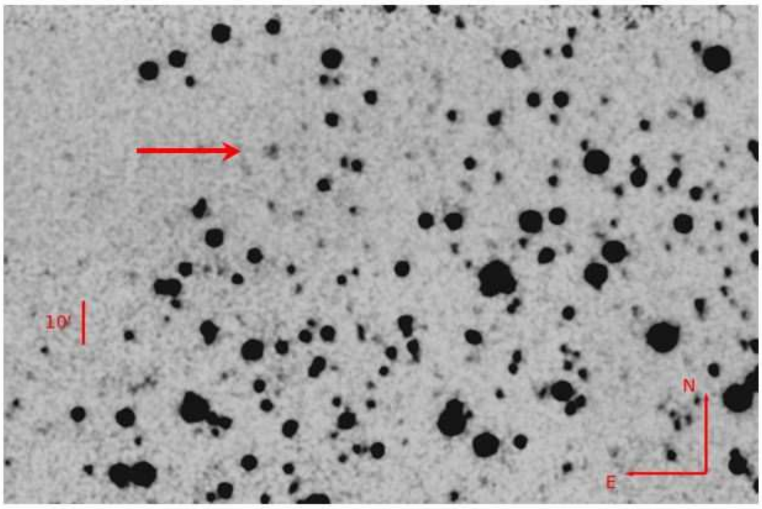

Figure 2: R-band image (480s exposure on the 2.5m Isaac Newton Telescope) of the object. It is clearly seen that the object is extended.

Several SNRs have been studied in detail at optical wavelengths (Ritcher et al. 1995, Gerardy et al. 2001, Morel et al. 2002, Stupar et al. 2007, Stupar et al. 2009). These objects have many strong emission lines in the entire X-shooter range, as presented in the 'Catalog of UV, optical and near-IR emission lines identified in SNRs' (Fensen et al. 1996), including the very strong [O III] (5007 Å). Ratios between several of these lines have consistent and well defined values for SNRs (e.g. $I([\text{O III}])/I(\text{H}\beta)$, $I([\text{S II}])/I(\text{H}\alpha)$), which differ from those of PNe. Thus the optical emission line ratios, combined with the line widths, are very good diagnostics to probe SNR.

The object presented here has very bright emission lines, albeit a faint continuum (being located behind a molecular cloud). The high resolution of X-shooter, combined with its wide wavelength range and an 8-meter class telescope make it possible the detection of several emission lines in a reasonable exposure time. The data will provide confirmation of this new SNR, a result worth of such small investment in time.

If confirmed, this object will be the 2nd SNR discovered by its infrared properties (Morris et al. 2006).

Targets and observing mode

Target	RA	DEC	R mag	Mode (slit/IFU)	Remarks
serp18	18 28 27.20	+00 44 45.0	22	slit	First priority

Time Justification:

It is possible to calculate the object's flux in the R-band from its magnitude (R = 22 mag). That gives a total flux in R of $\sim 1 \times 10^{-14}$ erg/s/cm^2. Naively assuming that $\sim$10% of this flux is due to any of the bright optical nebular emission lines such as [O II], [O III], Hα, [N II] or [S II] (consistent with the extreme line fluxes seen in the IRS spectrum), it is possible to estimate the line flux of [O III] to $\sim 1 \times 10^{-15}$ erg/s/cm^2.

Using the X-shooter Exposure Time Calculator Version 3.2.8 in line mode, we calculate that $S/N \sim 100$ can be obtained for [O III] with a total exposure time of 3000s. This total exposure time guarantees detection of lines up to 2 orders of magnitude fainter. Considering overheads, the total requested time is 1 hour.

References:

Fensen & Hurford, ApJSS 1996, 106, 563 • Gerardy & Fensen, AJ 2001, 121, 2781 • Ghavamian et al., ApJ 2009, 696, 1307 • Morel et al., MNRAS 2002, 329, 398 • Morris et al., ApJL 2006, 640, 179 • Ritcher et al.,ApJ 1995, 454, 277 • Sandstrom et al., ApJ 2009, 696, 2138 • Sandstrom et al., The Evolving ISM in the Milky Way and Nearby Galaxies 2009 • Stupar et al., MNRAS 2007, 381, 377 • Stupar & Parker, MNRAS 2009, 394, 1791