LBT/LUCI Observations of Warm, Dense Gas in the Irregular Galaxy NGC 1156

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Introduction

Deep narrow band NIR imaging allows to detect and analyse a previously neglegted phase of the diffuse interstellar medium in strongly starfoming galaxies: warm, dense gas, as traced by H_2 emission lines in the NIR and MIR. With the detection of H_2 emission in the galactic outflow/wind of M82 and the starburst core of M82 (Veilleux et al. 2009), the importance of this phase for the structure, mass, and coolingr processes of starbursts and their outflows was demonstrated.

The M82 study showed that there is sometimes, but no always a one to one match of the diffuse H_2 with the Hα and PAH emission, implying varying excitation mechanisms at work.

There are unfortunately not many deep H_2 images of strongly starforming galaxies, specially lower metallicity galaxies are largely absent. We started a program to observe H_2 in dwarf starbursts and present here first observations of NGC 1156 using LBT/LUCI.

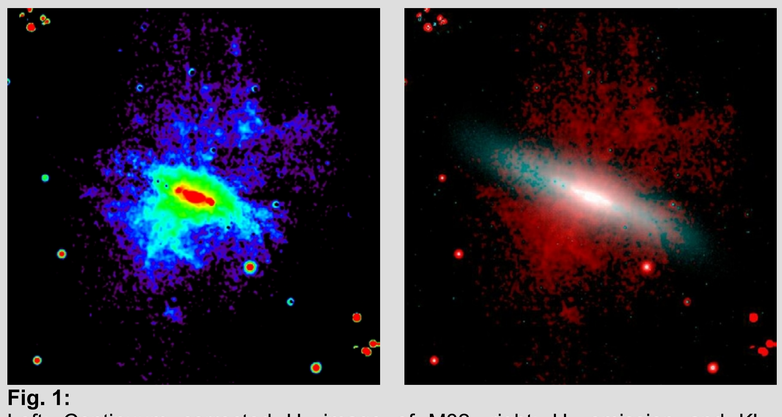

Fig. 1:
Left: Continuum corrected H_2 image of M82, right: H_2 emission and K' continuum of M82. Both images are take from Veilleux et al. 2009.

Observation

We observed NGC 1156 with LBT/LUCI-1 in the K' filter and H_2 2.12μm bands getting 0.1h and 1.1h on-source time. Seeing condition were good at the time of the observations with ~0.5" FWHM for both filters.

Unfortunately the observation script did not fully work as intended, so that there were problems with the dithering of the data. This resulted in major problems during data reduction and limited our sensitivity in the areas NE and SW of the main body of NGC 1156. Obviously the sensitivity of the H_2 image needs to be further improved for a detailed analysis of the filamentary structures.

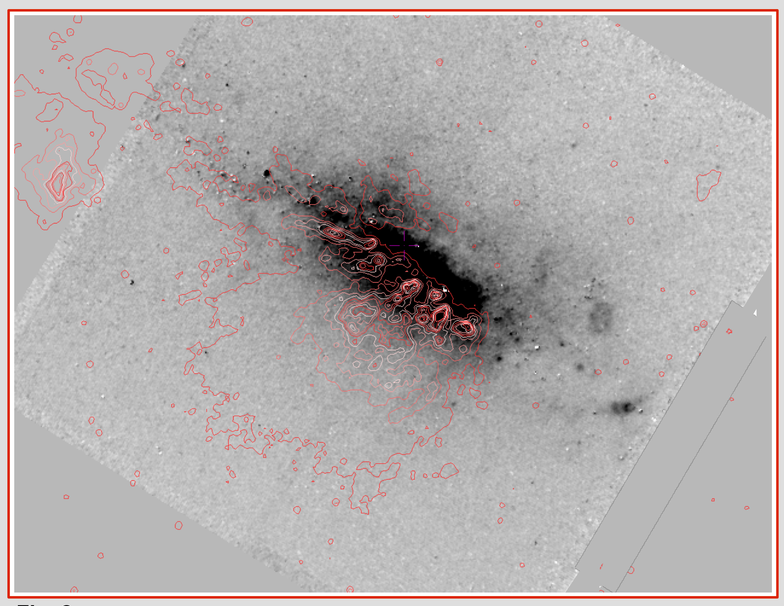

Fig. 2:
Core of NGC 253, the grayscale image shows the continuum corrected H_2 emission from HST with red contours of the continuum subtracted Hα emission from a HST WFPC2 dataset overlayed.

Another case for H_2 in galactic outflows

While we do not reach the sensitivity yet in NGC 1156 to trace out the diffuse filaments out of the disk of the galaxy, there is at least one other case with H_2 filaments extending from an starburst regions out of the disk into the lower halo: NGC 253. Currently we analyze the HST data. First results are presented below in Fig. 2.

The H_2 fills the whole starburst core with bright diffuse emission and large filaments emanate from the core. The SW filament is embedded into the Hα emission, while the SE limits the Hα emission cone. H_2 filaments are also seen towards the N without Hα correlation, which is most probably due to the strong absorption. Still, the base of the galactic outflow/wind appears asymmetric in the H_2 emission, indicating differences in mass loading, pressure, or excitation.

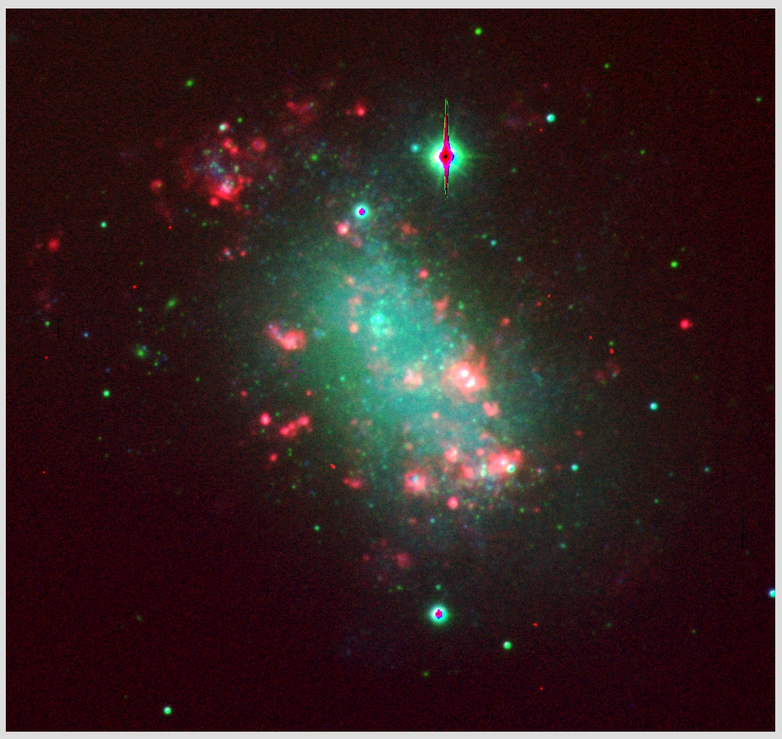

Fig. 3:
Color image of NGC 1156 (blue: B band, green: I band, red: continuum subtracted Hα. The images were taken with the ALFOSC instrument at the 2.56m NOT (Soren-Larsen & Richtler 1999).

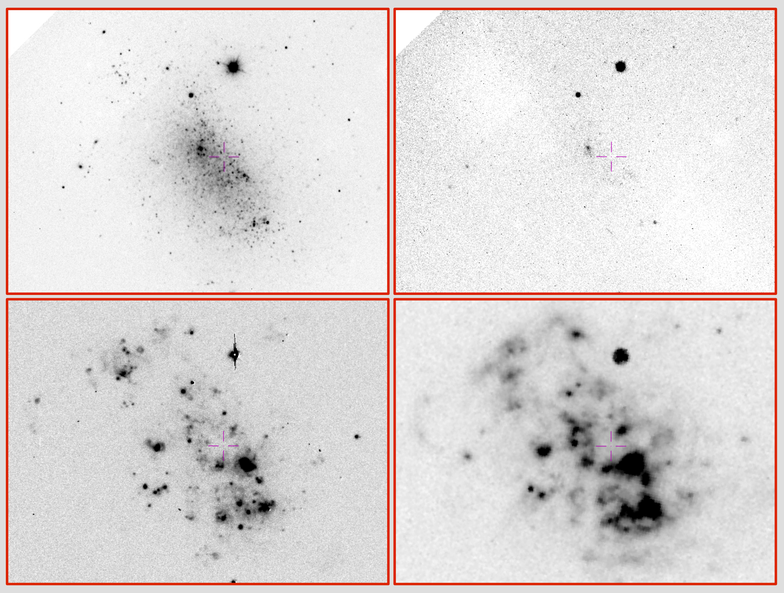

Fig. 4:
NGC 1156: upper left: our LUCI image in K', upper right: LUCI image in continuum corrected H_2, lower left: Hα, lower right: Spitzer 8μm (PAH).

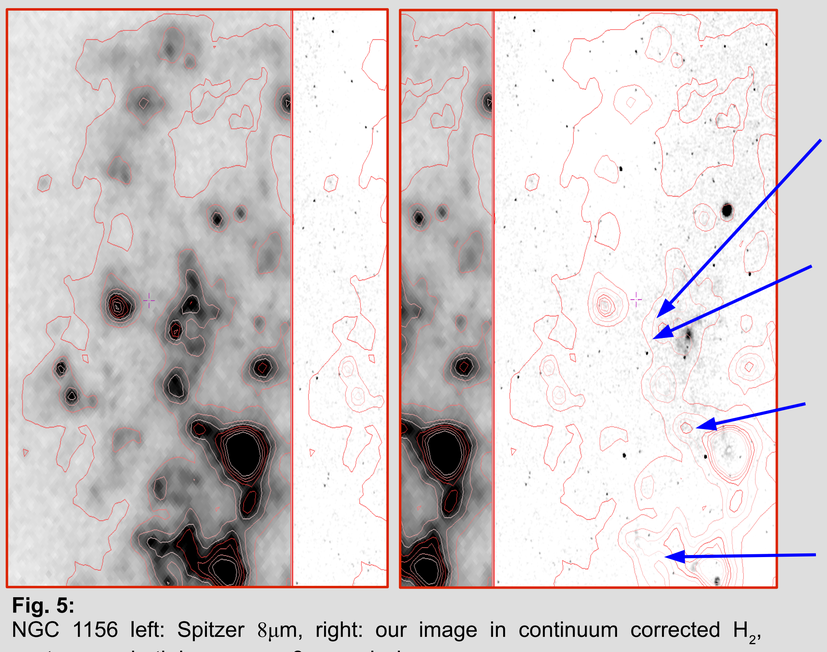

Fig. 5:
NGC 1156 left: Spitzer 8μm, right: our image in continuum corrected H_2, contours on both images are 8μm emission

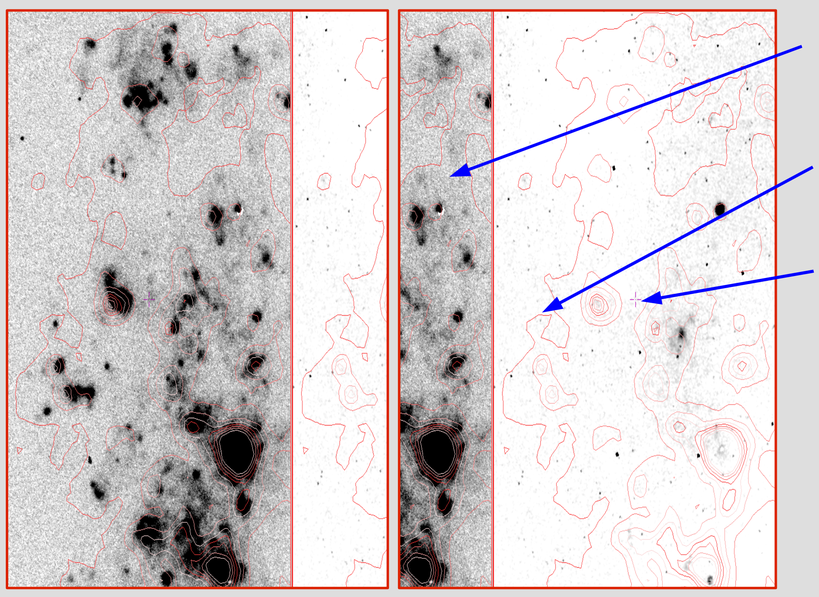

Fig. 6:
NGC 1156: left: Hα image, right: LUCI image in continuum corrected H_2, contours on both images are 8μm emission again.

NGC 1156

The target galaxy is an isolated irregular galaxy at the distance of ~6 Mpc, whose morphology and global properties make it appear as a smaller cousin of the prototypical starbursting irregular galaxy NGC 4449.

A Spitzer spectrum of one region in NGC 1156 only showed a marginal detected of H_2 in emission (Hunter & Kaufman 2007).

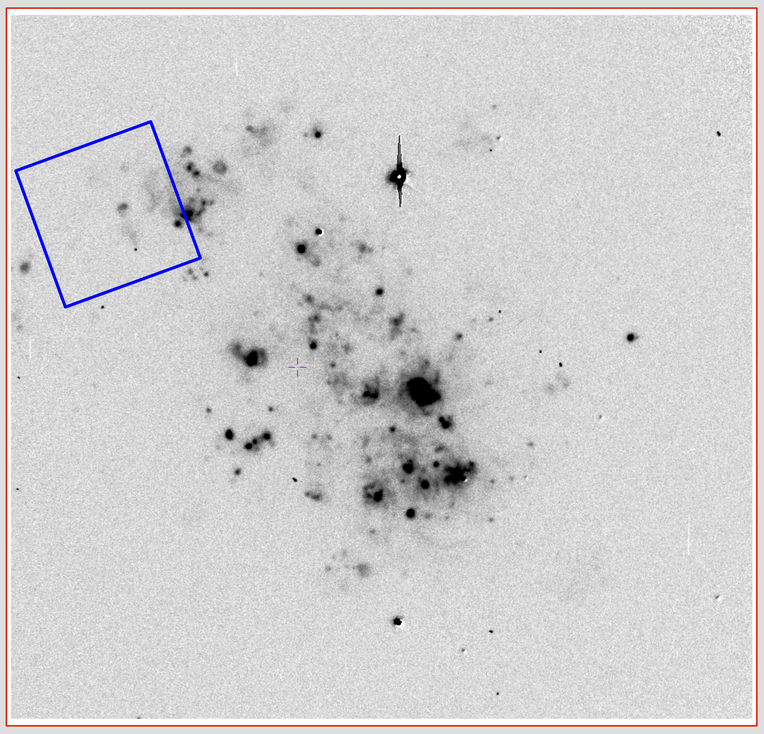

Fig. 7:
Location of the Spitzer IRS aperture of the spectrum shown in Fig.6 overlayed on our Hα image. Note that the region is not covered by the region of highest sensitivity of our H_2 imaging data.

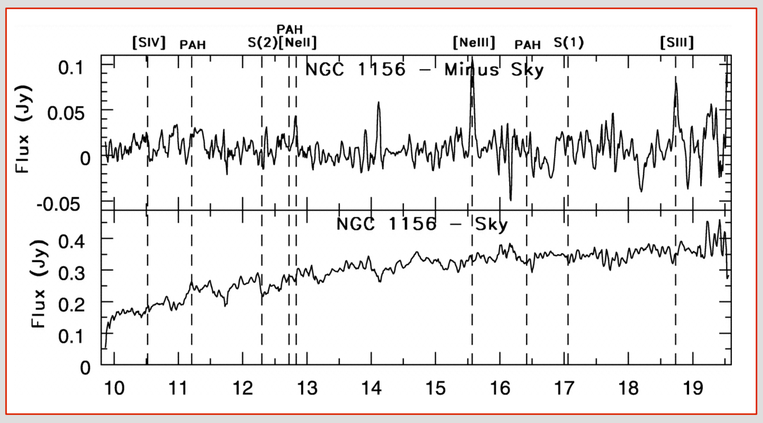

Fig. 8:
Spitzer IRS spectrum of the NE region of NGC 1156 (Hunter & Kaufman 2007). Note the marginal detection (or non-detection) of H_2 lines.

Brightest H_2 spot in NGC 1156, located in a local mininum of the PAH emission and Hα emission.

Bright diffuse arc south of the bright H_2 spot, coincides with an PAH arc and diffuse Hα emission.

Faint H_2 emission correlated with an bright PAH filament, but avoids the much brighter PAH and Hα emission blob to the west.

H_2 emission blob at the end of a bright PAH filament, and coinciding with an HII region.

Isolated H_2 cloud with PAH counterpart, but no Hα emission, far from regions of strong ionizing radiation.

Another isolated H_2 cloud offset from an HII region and spatially coincident with a bright PAH region.

Extended, very faint H_2 emission with corresponding diffuse Hα emission and PAH emission.

Conclusions

* clumps and filaments of H_2 detected in NGC 1156
* only partly coincident with PAH emission
* only partly coincident with Hα emission
* warm dense gas appears widespread in strongly starforming galaxies
* H_2 emission may be fainter at lower metallicity