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 neglected phase of the diffuse interstellar medium in strongly starforming galaxies: warm, dense gas, as traced by H$_\alpha$ 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 cooling 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$_\alpha$ with the H$_\alpha$ and PAH emission, implying varying excitation mechanisms at work.

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

Fig. 1: Continuum corrected H$_\alpha$ image of M82, right: H$_\alpha$ emission and K$'$ continuum of M82. Both images are taken from Veilleux et al. 2009.

Fig. 2: Color image of NGC 1156 (blue: B band, green: I band, red: continuum subtracted H$_\alpha$). The images were taken with the ALFOSC instrument at the 2.56m NOT (Soren-Larsen & Richtler 1999).

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

Obvisouly the sensitivity of the H$_\alpha$ image needs to be further improved for a detailed analysis of the filamentary structures.

Fig. 4: NGC 1156: upper left: our LUCI image in K$'$, upper right: LUCI image in continuum corrected H$_\alpha$, lower left: H$_\alpha$, lower right: Spitzer 8$\mu$m (PAH).

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 H$_\alpha$ emission, while the SE limits the H$_\alpha$ emission. H$_\alpha$ filaments are also seen towards the N without H$_\alpha$ correlation, which is most probably due to the strong absorption. Still, the base of the galactic outflow/wind appears asymmetric in the H$_\alpha$ emission, indicating differences in mass loading, pressure, or excitation.

Fig. 5: NGC 1156 left: Spitzer 8$\mu$m, right: our image in continuum corrected H$_\alpha$, contours on both images are 8$\mu$m emission.

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 starforming 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: 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 minimum of the PAH emission and H$_\alpha$ emission.

Bright diffuse arc south of the bright H$_2$ spot, coincides with an PAH arc and diffuse H$_\alpha$ emission.

Faint H$_2$ emission correlated with an bright PAH filament, but avoids the much brighter PAH and H$_\alpha$ emission blob to the west.

H$_2$ emission blob at the end of a bright PAH filament, and coinciding with an HII region.

.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.

Isolated H$_2$ cloud with PAH counterpart, but no H$_\alpha$ 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 H$_\alpha$ 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 H$_\alpha$ emission
*$ warm dense gas appears widespread in strongly starforming galaxies
*$ H$_2$ emission may be fainter at lower metallicity

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