Far infrared lines mapping of M32 with Herschel- PACS A. Contursi A. Poglisch, J. Graciá Carpio, E. Struck, Pavis and the



Full sampled PSF mapping [CII] @ 158 μm [OI] @ 145 and 63 μm



2.5

<u>M82</u>

*Archetypal starburst galaxy located at 3.53 Mpc

*2 episodes of starbursts at 10⁷ and 5x10⁶ yr ago the first triggered by encounter with M81 ~10⁸ yr ago, the second likely bar – driven (Förster Schreiber et al. 2003)

*Spectacular bipolar outflows detected in optical, UV, Xray, H₂ and dust.

*Outflows contain warm ionized gas at T ~ 10⁴ K with large filling factors

*Cool dusty material entrained by the outflows

WHY MAPPING THESE LINES?

- *[CII] and [OI @ 63] and [OI@ 145] mainly arise from (PDRs) where hv < 13.6 eV photons dominate the physics of the neutral ISM
- *Neutral ISM mainly heated via photoelectric effects on the grains. [CII] and [OI] main cooling lines
- *[CII] can be produced also in ionized medium
- *[OIII] only in ionized medium





Radial velocity





-80.0000

 45^8





Halpha

Halpha





1_{DUST}, F(50 μm), F(100 μm) AND FIR MAPS

* From continuum aside the lines AND parallel channels we fitted each pixels with gray blackbody (β =2)





ORIGIN OF [CII] and [OI] IN THE OUTFLOWS





NATURE OF THE OUTFLOWS

- *[CII] and [OI] in the outfows originate in clumpy PDRs
- *North and South outflows very different. Are they in two different evolutionary phases?
 - NW outflow seems to expand in a free flow.
 SW still in a bow shock phase, where shocks are more important than ionization (Heckman et al. 1990, Hoopes et al. 2005)?
- *Each related two one of the starburst episodes? NW related to the first?

PDR MODELING



Kaufman et al. 1999



PHOTOELECTRIC HEATING EFFICIENCY



PAHs major contributors to photoelectric heating



 $G_0 \sqrt{T/n_e}$ map assuming $n_e / n_H \approx 10^{-4}$ Contours = PAH intensity at 6.2 µm (ISOCAM data)



Conclusions

*Ionized/neutral medium best to highlight the outflows.

- *[CII] and [OI] arise from PDRs in disk and outflows but much more clumpy in the outflows.
- *Observed difference between outflows probably due to different evolutionary phases, perhaps related to the 2 starbursts episodes.
- *PAHs are mostly NOT ionized in M82 and their ionization degree does not vary with the parameter supposed to set their charge.

!!!!!!!This is just the beginning!!!!!!!

PDR MODELING

*G₀ proportional to n^{1.3} as found from global emission in star-forming galaxies. Predicted relation from PDR surrounding an HII region (Malhotra et al. 2001)

*PAHs are mostly neutral.

- *There seems *not* to be a trend of increasing ionization degree with $G_0\sqrt{T/n_e}$
- *May be very high (> 1e6) $G_0\sqrt{T/n_e}$ are necessary to significantly ionize the PAHs population as already predicted by models (Bakes and Tielens 1994)









Westmoquette et al. 2009

Halpha







