# Small-scale Properties of Atomic Gas in Extended HI Envelopes of Galaxies

# What can HI tell us about star

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#### Gas gas everywhere, nary a star being formed



# Small-scale Properties of Atomic Gas in Extended H1 Envelopes of Galaxies

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#### Wow! A bright Quasar behind the disk!



Borthakur et al. 2011, ApJ, 727, 52

#### Cold Gas in the HI Envelope

VLA D-configuration



## Physical Properties of HI



# Suppression of Condensation

- 90% of the HI fail to condense to cooler phase (< few 100 K)
   <p>Low Metallicity: Lower radiative cooling (Wolfire et al. 1995)

  So thermal equilibrium between warm and cold HI requires higher pressure
- 2. The cold phase (10% of HI) is unusually cold:  $\leq$ 25K
  - Gas in the Milky Way at  $\leq 25$ K is in the molecular phase.
  - Fraction of HI that was able to condense into the cold phase remains in the atomic state and avoids the transition to molecular phase.

Low Dust Content: Low photoelectric heating by dust grains. Impede molecule production

- 3. Similar narrow HI features seen in SMC (Dicket et al. 2000))
  - The dust optical depth of the HI shielding layer (Krumholz et al. 2009)
  - HI column densities required to detect molecules in

Milky Way  $\rightarrow$  N(HI)  $\geq$  5 x 10<sup>20</sup> cm<sup>-2</sup>

- LMC  $\rightarrow$  N(HI)  $\geq$  20 x 10<sup>20</sup> cm<sup>-2</sup>
- SMC  $\rightarrow$  N(HI)  $\geq$  100 x 10<sup>20</sup> cm<sup>-2</sup>

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## Solution: Metal Mixing?



(Hot mode, code mode, etc.)

(Turbulence, stellar feedback, recycled accretion, gravitational stress, etc.)

#### Low covering fraction of cold gas



## Cold Gas in the Stellar Disk of Galaxies



Borthakur et al. 2010, ApJ, 713, 131



Gaussian of FWHM = 3.6 km/s Kinetic Temperature ≤ 283 K

#### Spatial Extent of the Absorber: Parsec-scale structures



Contours are 3, 4, 5, and 6 times the rms noise of 1.5 mJy beam<sup>-1</sup>. Greyscale show the radio continuum.

#### Small-scale Properties of HI in Galaxies

(J2000)

Declination

Small covering fraction of cold gas in the ISM -  $f_{cov} \approx 25\%$ 

Simple kinematics in cold gas clouds

Atomic gas at extremely low temperatures – FWHM=  $1.1 \text{ km/s} \Rightarrow T_{\text{kinetic}} \le 26 \text{ K}$ 

Low column density of cold gas

Most of the neutral gas in the ISM is in the warm phase -  $M(HI)_{cold}/M(HI)_{total} \sim 10\%$ 

#### Indication of suppression of condensation

With SKA and its precursors, similar experiments can be performed for a much larger sample to explore correlations between condensation of HI and galaxy properties.

We NEED High Spatial and Spectral Resolution



mJy/Beam