Cold atomic gas around Perseus: HI saturation and "CO-dark" gas?

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Abstract

How exactly giant molecular clouds (GMCs) form out of the diffuse atomic medium is still not understood, however, neutral hydrogen (HI) envelopes frequently observed around GMCs likely play a very important role in the GMC evolution and may be able to explain long-standing questions, such as the origin of the internal turbulent energy in GMCs. In addition, cold and optically thick gas in HI envelopes could be responsible for: (i) the existence of the HI saturation in galaxies, whereby the HI surface density never excess 10 $M_\odot$ pc^{-2} (e.g. Schruba et al. 2011, Lee et al. 2012), and (ii) the "CO-dark" halos surrounding GMCs, as proposed recently by Fukui et al. (2014).

To address both questions, it is essential to obtain information about the cold and warm portions of HI envelopes. Using the Arecibo Observatory, we have obtained HI absorption observations in the direction of 27 strong background, radio continuum sources all in the direction of the Perseus molecular cloud. HI absorption is detected in all directions, and we characterize properties of cold gas (temperature and fraction) in the HI envelope around Perseus. We show that HI absorption traces the cold neutral medium (CNM) with spin temperature of 10–200 K. Only 20% of cold components in our study have a peak optical depth > 0.5, as opposed to Fukui et al. (2014) who suggested that $\sim$ 85% of lines of sight at $|b| > 15^\circ$ should have such high optical depth. We also correct HI emission observations of Perseus by Lee et al. (2012) for the presence of the high optical depth HI, and show that HI still saturates at $\sim$ 10 $M_\odot$ pc^2, as expected by equilibrium H_2 formation models for the minimum column density for shielding H_2.

Keywords
ISM: molecules – radio lines: ISM