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The interplay of dense gas and stars in M33

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Abstract. We are studying the interplay of star formation and its 'fuel', the molecular gas (diffuse and dense) at selected positions along the major axis of M33. We have observed the ground-state transitions of HCN, HCO^+, and ^{13}CO using the IRAM 30m telescope. These data will complement existing CO, HI, Spitzer, and radio continuum maps. Furthermore, these data will be complemented by far-infrared maps of [CII], H_2O, [OI], [NII], and the dust continuum taken with Herschel in the open time key project HERM33ES.

M33 is a spiral galaxy located at a distance of 840 kpc. Observations of small scale structures in M33 do not suffer from distance ambiguities like galactic observations do. The IRAM-30m beam at 89 GHz is 27″, which corresponds to only 92 pc. M33 is seen almost face-on allowing to study individual cloud complexes.

It is the nearest late-type galaxy, is chemically and dynamically young, roughly 10 times less massive than the Milky Way and with an overall metallicity subsolar by a factor 2-3. With a well-defined metallicity gradient (Magrini *et al.* 2007, Rosolowsky & Simon 2008), M33 is a particularly interesting object, filling in the metallicity gap between the Milky Way and the Magellanic Clouds. Studying metallicity effects, e.g. on the CO-to-H_2 conversion factor, is also of importance for interpreting the emission of objects at high redshifts.

Due to their large dipole moments, HCN and HCO^+ trace the dense gas ($n > 10^4$ cm^{-3}) in galaxies. And as stars condense out of the densest material, these molecules may be good tracers of the star formation rate (SFR). The role of HCN as tracer of the SFR was recently discussed by Wu *et al.* (2005), combining Galactic data with data of nearby galaxies and starbursts. They show that HCN is a much better tracer of star formation than CO (see also Gao & Solomon 2004). A similar conclusion should hold for HCO^+. Previous studies of the HCO^+/HCN ratio find values around 1, e.g. 1.1 in M31 (Brouillet *et al.* 2005) or 0.5 - 1.6 in a sample of galactic nuclei, depending only slightly on environment (Krips *et al.* 2008).

Using the IRAM 30m telescope, we detected HCO^+(1-0) and HCN(1-0) at several positions along the major axis of M33 out to 4 kpc. We find rather large HCO^+/HCN ratios of integrated intensities of ~ 10 in the central regions. In addition we find indications of a rise of HCN intensities with radius, while the SFR also drops with distance. More data are currently observed to secure this finding. The large HCO^+/HCN ratios in the center may reflect the low N/H abundance of M33. It is lower than the N/H solar value (Asplund *et al.* 2005) by a factor 5 or more (Magrini *et al.* 2007, 2009, priv. com.). We will use models of the chemical and physical structure of photon dominated regions (Roellig *et al.* 2007) to confirm this speculation.