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The Resolved Kennicutt-Schmidt Law in Nearby Galaxies

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Abstract. The Kennicutt-Schmidt law (Schmidt 1959; Kennicutt 1998, hereafter K-S law) is a power law correlation between area averaged star formation rate (Σ_{SFR}) and gas surface density (Σ_{gas}). Despite its importance, the physics that underlie this correlation has remained unclear. The power law index, N, is a prime discriminator of the mechanisms that regulate star formation and form the K-S law (e.g. Leroy *et al.* 2008; Tan 2010). We present a study of the resolved K-S law for 10 nearby disk galaxies using our new CO(1-0) data at 750 and 500 pc resolutions. The CO(1-0) line emission is established as a tracer of the molecular gas column density, and results in a super-linear correlation ($N = 1.3$ and 1.8). We discuss the cause of the discrepancy between previous studies, and the mechanism of star formation indicated from our new results.

Keywords. stars: formation — galaxies: spiral — ISM: molecules

1. Results and Discussions

We derive the K-S law on 750 pc scale by employing a similar procedure as Bigiel *et al.* (2008, hearafer B08), but with CO(1-0). The index at this scale shows a super-linear correlation with N=1.3±0.02. Furthermore we verify the K-S law on a 500 pc scale. The diffuse emission from both Hα and 24 μm subtraction is also examined on this scale as an example. The best fit linear regressions also result in a super-linear slope both without and with diffuse emission subtraction (N=1.2±0.05 and N=1.8±0.09, respectively).

Our result is different from B08 ($N \sim 1$). We find that the discrepancy of the slope between our results and B08 is caused largely by the adopted molecular gas tracer, CO(1-0) or CO(2-1). CO(2-1) has only a factor of 2-3 higher n_{crit} ($n_{crit} \geqslant 10^3$ cm^{-3}) and level energy (equivalent temperature of 16.5 K); and thus, is excited more when the density and/or temperature is higher than the typical (a few 100 cm^{-3}; 10 K) even just mildly. In fact, the ratio of observed CO(2-1) to CO(1-0) intensity ($R_{21/10}$) varies systematically with star formation rate and gas surface density in M51 (Koda *et al.* 2012). CO(2-1) likely traces the denser and/or warmer gas, rather than the bulk molecular gas in galaxies.

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