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The First Proto-Brown Dwarf Binary Candidate Identified through Dynamics of Jets

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Abstract. The formation mechanism of brown dwarfs (BDs) is one of the long-standing problems in star formation because the typical Jeans mass in molecular clouds is too large to form these substellar objects. To answer this question, it is crucial to study a BD at the embedded phase (proto-brown dwarf). IRAS16253 is classified as a Very Low Luminosity Object (VeLLO, $L_{\rm int} < 0.1L_\odot$), which is considered as a proto-brown dwarf candidate. We use the IRAM 30m, APEX telescopes and the SMA to probe the molecular jet/outflow driven by IRAS 16253 in CO (2–1), (6–5), and (7–6) and study its dynamical features and physical properties. We detect a wiggling pattern in the position-velocity diagrams of the jets. Assuming that this pattern is due to the orbital motion of a binary system, we obtain the current mass of the binary is $\sim$0.026 $M_\odot$. Together with the low parent core mass, IRAS16253 will likely form one or two proto-BD in the future. This is the first time that the current mass of a proto-BD binary system is identified through the dynamics of the jets. Since IRAS16253 is located in an isolated environment, we suggest that BDs can form through fragmentation and collapse like low mass stars.

Keywords. star: low-mass, brown dwarfs, stars: formation, ISM: jets and outflows, ISM: kinematics and dynamics

Results and Discussion

The SMA CO (2–1) map well matches the H_2 emission, suggesting that the CO emission traces the protostellar jet (Fig. 1). We plot a PV-diagram along the modeled precession jet locus and find wiggling pattern with small period in the position velocity space (Figure 2). We speculate that this wiggling pattern is caused by orbital motion of the binary system, which allows us to calculate the current mass of the central star(s) with Kepler's law ($M_{\rm tot} = \frac{4\pi^2}{GP_{\rm orb}^2}a^3$). We derive the current masses of the central stars as 0.02 $M_\odot$ and 0.006 $M_\odot$. This result, together with the low mass of the parent core (<0.5 $M_\odot$), implies that IRAS 16253 will form one or two BDs. Since IRAS 16253 is located in an isolated environment, we suggest that BDs can form like normal low mass stars.

Our CO (6–5) and CO (2–1) maps (from APEX and IRAM 30m) reveal very different morphologies (Fig. 3). While the CO (6–5) emission matches the H_2 jet locus well, the CO (2–1) integrated intensity is shifted to the east of the H_2 jets, likely probeing the outflow entrained gas and cavity wall detected in scattered light with IRAC 1. We further derive an very low outflow force based on the multi-transition CO data, which supports that IRAM 16253 is likely an proto-brown dwarf binary system.

Results and Discussion

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