【Grant-in-Aid for Scientific Research (S)】

Broad Section B

Title of Project： The earliest stage of star formation to be studied by observing deuterated molecules

TATEMATSU Ken'ichi

(National Astronomical Observatory of Japan, Nobeyama Radio Observatory, Professor)

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Keyword：star formation, molecular cloud core, starting mechanism, deuterium

【Purpose and Background of the Research】

The importance of radio astronomy observations of deuterated molecules is increasing. First, it was found that most of molecules are depleted onto the dust grain, and therefore it is hard to observe cold (10-20 K) starless molecular cloud cores (prior to the formation of the protostar) through with the cutting-edge radio telescope ALMA, which has an extremely high spatial resolution. Then, deuterated molecules, which are less affected by depletion and can provide kinematical information through Doppler shift, are becoming valuable for the ALMA era. Second, it is becoming clear that the deuterium fraction reaches its maximum just before and after the onset of star formation. The deuterium fraction monotonically increases before star formation, and monotonically decreases afterward.

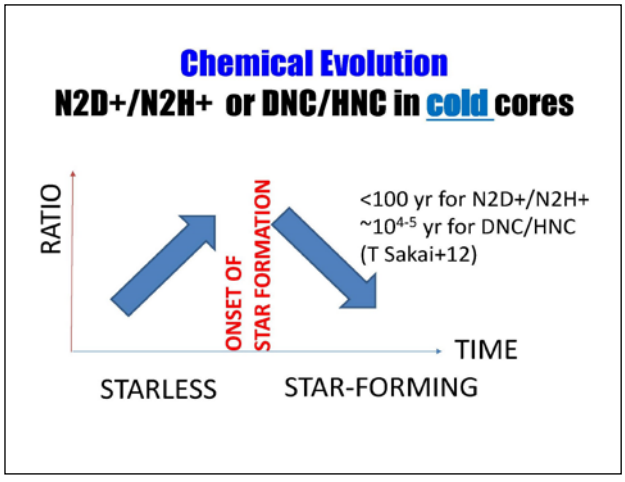

Figure 1 Schematic drawing of the change of the deuterium fraction.

【Research Methods】

For this research, we will newly develop a cutting-edge 7-beam 72-116 GHz receiver system to be installed on the Nobeyama 45-m radio telescope. We will carry out survey observations of representative star forming regions. The receiver employs 72-116 GHz low-noise amplifiers to allow 7-beam and dual-polarization observations. We will develop the receiver in the 1st and 2nd years, will make commissioning of the receiver in the 3rd year, and will conduct survey observations toward representative star forming regions in Taurus, Ophiuchus, Orion and Infrared Dark Clouds, which have different star forming activities, and make a comparative study among regions. In addition, we will make follow-up observation using ALMA.

【Expected Research Achievements and Scientific Significance】

In this research, we will employ the Chemical Evolution Factor which we introduced and established using the deuterium fraction, together with protostellar information. We will classify molecular cloud cores in to four stages: early starless, mid starless, late starless, and protostellar. Then, we will carry out statistical study of the evolution of molecular cloud cores to achieve the above purpose.

We like to pinpoint the starting mechanism of star formation. Candidate mechanisms are dissipation of turbulence, mass accretion, decrease of supporting magnetic fields, etc. If dissipation of turbulence is important, we will be able to observe its decrease along the core evolution. If mass accretion is important, we will see increase in core mass. Statistical study based on the Chemical Evolution Factor should allow us to make significant progress in this field.

【Publications Relevant to the Project】

· Ken'ichi Tatematsu, Tie Liu, Gwanjeong Kim, Hee-Weon Yi, Jeong-Eun Lee, Naomi Hirano, et al. "ALMA ACA and Nobeyama observations of two Orion cores in deuterated molecular lines," ApJ, 895, 119 (2020)

· Gwanjeong Kim, Ken'ichi Tatematsu, et al., "Molecular Cloud Cores with High Deuterium Fraction: Nobeyama Single-Pointing Survey," ApJS, 249, 33 (2020)

【Term of Project】 FY2020- 2024

【Budget Allocation】 158,000 Thousand Yen

【Homepage Address and Other Contact Information】

https://www.nro.nao.ac.jp/~kt/html/kt-e.html