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

Broad Section B

Title of Project : Chemical Composition of Disk Forming Regions of Solar-type Protostars and its Evolution to Planetary Systems

Satoshi Yamamoto
(The University of Tokyo, Graduate School of Science, Professor)

Research Project Number : 18H05222 Researcher Number : 80182624
Keyword : Radio Astronomy

【Purpose and Background of the Research】

A detailed understanding of the evolution of matter during star and planet formation is of fundamental importance in elucidating the origin of the Solar System. In this project, we will explore the chemical diversity of protostellar sources and its evolution to planetary systems through high-resolution radio observations with ALMA. The main goals are (1) to reveal an entire view of the chemical diversity by observations of about 20 protostellar sources, (2) to resolve the transition zone from the envelope to the disk for a few representative sources at the highest angular resolution of ALMA, and (3) to investigate the origin of the chemical diversity in a statistical way by observing many protostellar sources in a single molecular cloud complex. For the 5 year term of this project, we are going to reveal basic laws of the chemical evolution of protostellar sources for understandings of our origin in the universe.

【Research Methods】

To achieve the above goals, we are going to conduct extensive observations of molecular lines with a full use of ALMA.

(1) Evolution of Chemical Diversity: So far, the observational data with a resolution of a few 10 au have been delivered for a few sources. We are going to analyze these data, and to prepare proposals for further ALMA observations. For 5 years, we will eventually explore about 20 protostellar sources, and reveal basic laws of the chemical evolution. In addition, we will study chemical processes in disk forming regions by chemical network calculations.

(2) Chemical and Physical Processes in Disk Forming Regions: Complex physical and chemical processes, including a launch of outflows, seem to occur around the centrifugal barrier of the infalling-rotating envelope gas. We will reveal its detailed structure at the highest angular resolution.

(3) Origin of Chemical Diversity: Observations of a number of protostellar sources in the Orion and Perseus clouds have already been conducted with ALMA. Chemical diversity and its origin will be studied in a statistical way by using the CH_3OH and CCH lines. We will propose ALMA observations of other molecular complexes for comparison.

In parallel to the observational studies, we are going to conduct laboratory measurements of rest frequencies of molecular lines including those of isotopic species with an accuracy better than 0.01 MHz by using a new submillimeter spectrometer at RIKEN. The obtained rest frequencies will widely be used for the above ALMA analysis.

【Expected Research Achievements and Scientific Significance】

This is the first attempt of systematic studies of chemical evolution in disk forming regions by a full use of ALMA. The result will provide us with crucial information on how chemical diversity of the envelope is inherited into planetary systems. It will significantly contribute to our understanding of the initial chemical environment of the Solar System in combination with results expected from exploration of small Solar System bodies

【Publications Relevant to the Project】

・Sakai et al., 2014, Nature, 507, 79-80.
・Oya et al. 2016, Astrophys. J. 824, 88 (19 pp).
・Sakai et al. 2017, Mon. Not. R. Astr. Soc. 467, L76-L80.

【Term of Project】

FY2018-2022

【Budget Allocation】

144,500 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.resceu.s.u-tokyo.ac.jp/~submm/

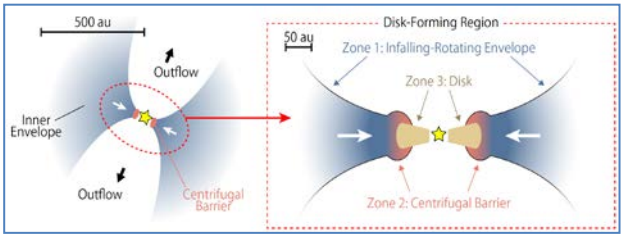

Figure 1: Structure of disk forming region to be studied with this project.