Spectroscopic Study of Solid Molecules around Extragalactic Young Stellar Objects with SPICA

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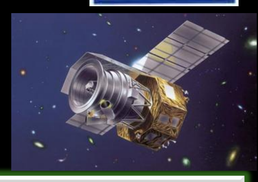


ABSTRACT

■AKARI has been pioneering the spectroscopic study of extragalactic YSOs, and discovered that chemical properties of solid materials around YSOs are different in a metal-poor galaxies
■However, current studies are limited to massive YSOs and low-resolution spectroscopy
■SPICA is expected to enable the detailed spectroscopic observations of massive YSOs and also lower mass YSOs in the nearby galaxies such as LMC/SMC

1. INTRODUCTION

Important 3 keywords in this study,

Ices around YSOs

- Important reservoir of heavy elements and complex molecules around embedded YSOs (Tab.1, Fig.1)
- Origin of cometary and planetary ices (Tab.1)
- Observed mainly by infrared absorption bands
- Formation mechanisms of ices around YSOs are not understood well

Extragalactic YSOs

- How do chemical conditions of materials around YSOs vary in other galaxy?
- Very few spectroscopic observations of ices toward extragalactic YSOs so far

The Large Magellanic Cloud (LMC)

- The nearest (~50kpc) irregular galaxy to our Galaxy
- An ideal environments for the study of extragalactic YSOs due to its proximity and low metallicity

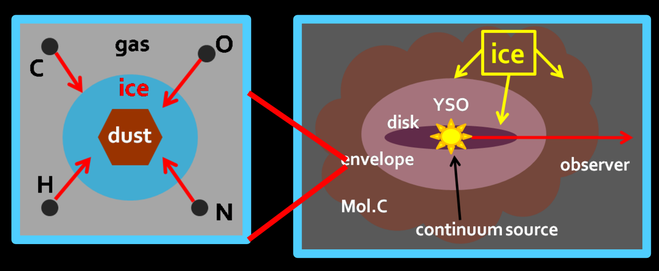


Fig.1 Ices, YSO, and the LMC

Table.1
Abundances+ of Ices toward Various Objects[1,2]

Molecule	Galactic YSO [%]	Comets [%]	Extragalactic YSO
H_2O (water)	---	---	?
CO_2 (carbon dioxide)	17--32	3-6	?
CO (carbon monoxide)	1—50	7-20	?
CH_4 (methane)	1—2	0.2-1.2	?
CH_3OH (methanol)	2—5	~2	?
NH_3 (ammonia)	3	~1.5	?

+Ratio of a column density relative to H_2O ice

In short, questions that we investigate are,

■Are chemical properties of solids around extragalactic YSOs different from Galactic ones ?
■How the metallicity of galagxies affect the chemistry around YSOs?

2.AKARI OPENED THE DOOR OF SPECTROSCOPIC STUDY OF EXTRAGALACTIC YSOs

AKARI, for the first time, conducted the systematic study of solid molecules around extragalactic YSOs, and discovered the following two important facts.

Observational Fact 1 (Fig.4)
Abundance of CO_2 ice around LMC's YSOs is higher than that of Galactic YSOs.

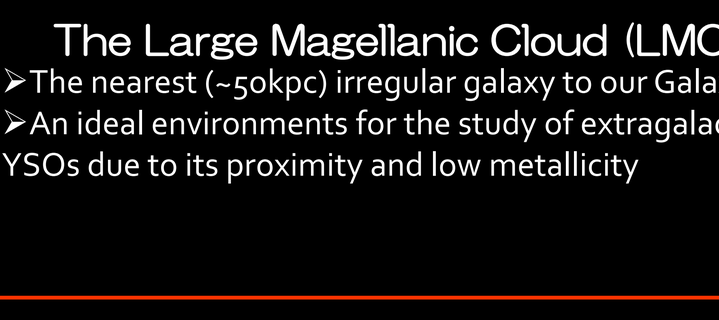


Fig.2 Examples of AKARI NIR spectra of LMC's YSO. Absorption features of major ice species are detected in the spectra.

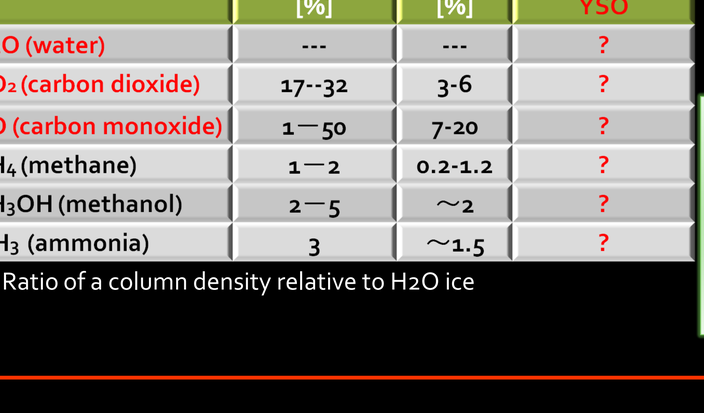


Fig.4 H2O vs. CO2 column density. Open and filled squares represent results of LMC's YSO and that of Galactic massive YSOs[1,2], and two solid lines represents their CO2/H2O ratio.

Implication

Generally high dust temperature[7] and/or the strong UV radiation field[8] in the LMC may be responsible for the high CO_2 ice abundance around YSOs in the LMC.

3. SPICA EXPAND THE POSSIBILITY OF EXTRAGALACTIC YSO STUDY

Current studies of extragalactic YSOs are limited to
- Massive (luminous) YSOs
- Low-resolution spectroscopy

However,

Ices play more important role in the planet-forming process, thus observations of intermediate-/low-mass YSOs are very important

High sensitivity of SPICA/MCS enables spectroscopy of intermediate-mass YSOs in the LMC/SMC. This provides very important information for the understanding of the planet formation and its chemistry in metal-poor environment.

Wavelength coverage and high spatial resolution of SPICA/MCS enables detection of minor ice species and detailed comparisons with laboratory ice spectra.

Detailed comparison of observed ice feature with laboratory data is necessary to extract chemical composition of ice mantle.

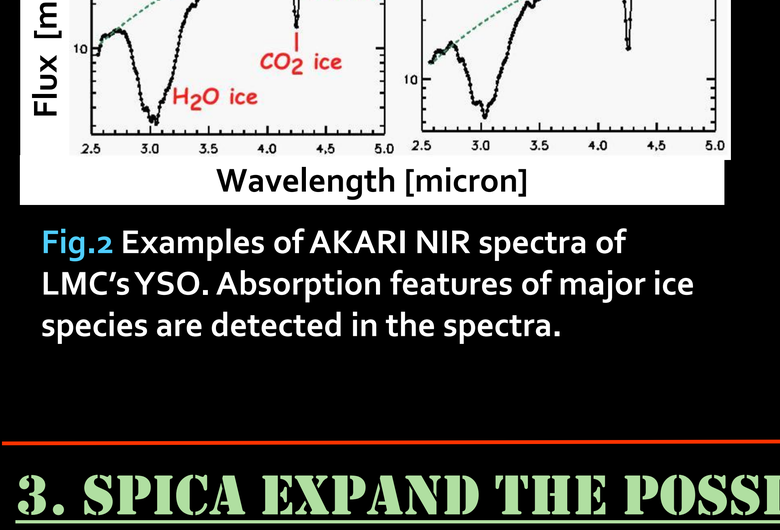
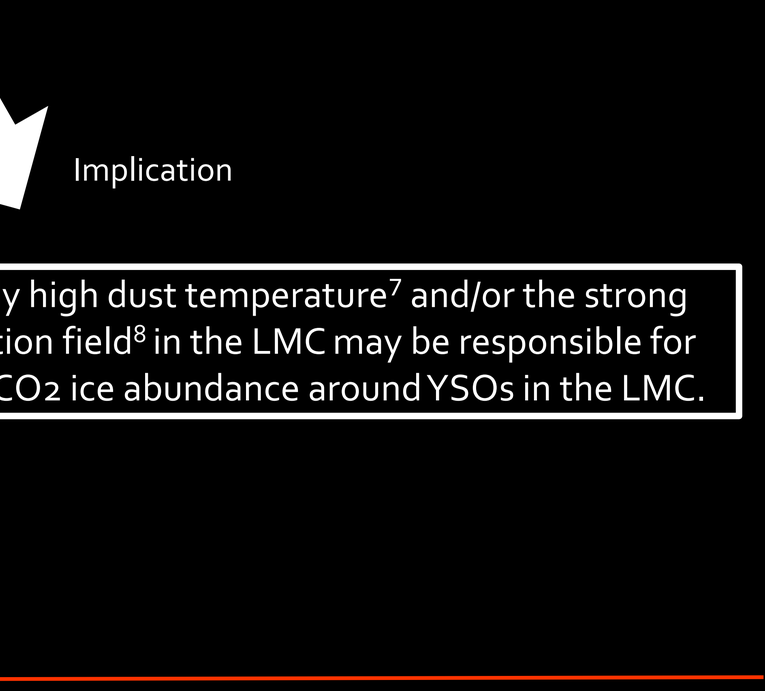


Fig.6 Infrared spectra of an embedded YSO W33A[6] . Position of various ice features are labeled. Expected wavelength coverage of SPICA/MCS is over-plotted.

Fig.5 Theoretically-predicted infrared luminosity and color of YSOs[3] at the distance of the LMC (50kpc). Detection limit of AKARI, Spitzer and SPICA/MCS spectrometer are indicated.



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