Method to measure lattice disorder of cosmic dust from infrared spectroscopy

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1 Introduction

Diagnosis of diversity of cosmic dust from comparison study between observation and laboratory spectroscopy is one of a most important issue of astromineralogy. Fundamental parameters obtained from observations are position, width and intensity of absorption or emission peaks. There are many factors which affect the observational parameters. In the past, behavior of spectral dependencies on chemistry, temperature, crystallinity, morphology (particle shape, size, agglomeration), matrix effect and so on were investigated precisely for crystalline silicate species. Among these factors, crystallinity (or lattice disorder) is becoming a noticeable and important factor to explain observation better. So far, from an experimental point of view, it was pointed out that a reproduced spectrum, which was calculated from optical constants by use of single crystal without lattice defects, gives smaller FWHMs than those of observation, generally. According to Chihara & Koike (submitted to A&A), it was suggested that when we assume existence of some disorder in lattice structure of circumstellar dust, FWHMs become large and observational results can be better explained.

Here in this work, from a view point of IR spectroscopy, we will propose a new method to estimate crystallinity of ambient cosmic dust located around stars.

2 Physical Justifications

From a fundamental base of spectroscopy of solids, integrated strength of absorption peak represents number of oscillator par unit volume of specimen. And *"Sum rule"* guarantees that the integrated strength of a peak is always constant, unless solid state properties of the specimen change. In a case that lattice disorder exist in the specimen, the number of oscillators must be reduced. Then, it is expected that the integrated strength of a peak also reduced. Therefore, it can be used as an index to measure lattice disorder. Here, we assume that the integrated strength is approximated as product of FWHM $\times$ intensity, it is expected that correlation between FWHM and intensity should be lie on a reciprocal curve. In order to verify this expectation, we measured FIR absorption spectra for some olivine samples with various lattice disorder at from room temperature to cryogenic temperature.

3 Results and Discussion

The measurements were carried out at Astrophysical Institute of Friedrich-Shiller University Jena with collaboration from Dr. Harald Mustchke and Simon Ziedler. In the correlation plot of FWHM and intensity, each data set with same disorder lied on a same reciprocal curve at any temperature (300, 200, 100 and 50 K). And we could confirm that as the degree of lattice disorder became larger, its reciprocal constant become smaller. It should be noticed that value of the index does not change at any temperature. It means that we can get information of crystallinity of specimen even from one measurement at only a certain temperature, if an ideal measurement can be done.

In the workshop, feasibility of this method to apply observation will also be discussed.