The dissipation of protoplanetary disks

Jean-Paul MELISSE[1,2], Stéphane GUILLOTEAU[1], Vincent PIÉTU[2], Emmanuel DI FOLCO[1]
[1]Laboratoire d'Astrophysique de Bordeaux, France
[2]Institut de RadioAstronomie Millimétrique, France

Protoplanetary disks play a major role in the formation of planets. They are composed gas and dust (99% and 1% like ISM). The transition between protoplanetary disks and the planetary formation has not fully known us. The aim of this project is to study and understand the dissipation mechanisms in protoplanetary disks around low-mass stars (< 3 $M_{\odot}$) and luminosity (M0 or more). For this we look for faint disk whose faintness can be a sign that they are in the dissipation phase. The study of these disks is bad enough known especially for small disks because they are more difficult to observe.

In order to study the characteristics of the disks, we use observations (infrared and millimeter) and we use astrochemical aspect of the disks. Some gases such as CO can be used as a tracer and identify structures inside the disk. We use the radiative transfer equation which describes the formation of a radio wave emitted by a linear molecule at low temperature (10 – 20K). Thus we can use the chemical properties of gas and dust (abundance of molecules) and a simple disk model (DiskFit, see [1]) to determine the physical parameters of disks such as its position, its inclination, its temperature, the mass of the star, and so on.

As a first step, our study was focused on one particular object, GO Tau, where it was studied in all its aspects; chemical compositions, dust to gas ratio and other physical parameters. 3mm GO Tau data taken by the NOEMA telescope in 2018. This data is first cleaned and calibrated before being analyzed. Dust emission gives us clues about the geometry of the disk and molecular emission such as HCO+ has shown the presence of a molecular cloud that hides part of the disk (spectrum absorbed by the cloud). In making D/H and C/N atomic ratios, we can trace the internal structure of the disk (presence rings for GO Tau).

Then, we looked at 3 sources with a small continuum disk: BP Tau, CX Tau and DE Tau. These 3 sources were observed with the NOEMA telescope during 2021. We looked for the same molecules that are present in large disks and we detected them all. We see a diversity of molecular abundances among these 3 sources. The resolution of the NOEMA data for these 3 sources is too low that it is difficult to determine whether they have disk structures.

Now the next step is to compare the chemistry (line ratio) of these disks to the large disks. Existing ALMA and NOEMA data will be used to compare disk properties with current dissipation models. Complex disk models (created from codes like Polaris [2] and Nautilus [3]) can be used for future studies.

References

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