Wide band spectral surveys : use of NOEMA and IRAM 30m in the study of the chemistry of a young protostar

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L1527 is a borderline Class 0/I protostar located in the Taurus molecular cloud, at a distance of 130 pc. Many observations have been done to study the properties of the disk, resulting in a good characterization of the small scales (a few tens of au). But the envelope properties on larger scales (a few hundred to a thousand au) are much less known. My first year PhD is aiming at characterizing the chemistry and the kinematics of the gas infalling from the envelope onto the nascent protostar. Thus, I needed wide frequency bands in order to have a anbiased spectral survey of the species present in L1527 and be able to detect species that are outside the known and bright ones.

For this purpose, the radio interferometer NOEMA has a spectral survey mode allowing to cover the 3 mm band (from 72 GHz to 112 GHz) using only three setups in frequency. This observation mode also allows the mapping of regions up to 95x95 arcsec in a single pointing, with a resolution 4 arcsec. This mode thus allows us to have a wide frequency band on an extended region while having sufficient spatial resolution to resolve details in the source. L1527 being an extended source, short-spacing using the IRAM 30m telescope are also needed on the whole spectral band and spatial region. This way of doing spectral surveys being recent, it can lead to some unexpected difficulties during the reduction and the merging of the data, especially because NOEMA and the 30m frequency bands do not perfectly match each other. The fact that the spectral resolution is low, especially at 3mm (250 kHz), can also limit the analysis in some ways (impossibilities to compute velocity maps for example). These are some of the difficulties I encountered during the first few months of my PhD.

The data cubes resulting from such surveys are also quite big, meaning it is not possible to calculate the column density and the excitation temperature of the detected molecules by hand for each pixel. The analysis of these datasets thus requires specific tools, such as the IRAM software GILDAS (and more specifically the package CUBE). The Python package pyspeckit can also provide ways to calculate important physical quantities for a whole data cube. Exploring these options is also an important part of my first year of PhD.