Refining Dust Properties in Protostellar Envelopes and Disks: Insights from ALMA, NOEMA, and NIKA2 Observations (PEBBLES/ENYGMA)

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Dust is one of the key elements in the physical processes regulating the formation of stars and their planetary systems, but recent observations are overturning the models used until now to describe its evolution from submicron grains to pebbles. Observing and modelling the properties of dust grains during the earliest phases of disk formation promises to provide important insights into the conditions leading to the formation of solar systems such as our own. The PEBBLES project seeks to develop a methodology for characterizing dust properties in protostars. By combining size-sensitive dust observations and new astrophysical models, the project aims to enhance our understanding of dust in protoplanetary disks, a key factor in early planetary system formation. It will explore the evolution of dust during star formation and its role in linking the magnetic field to surrounding matter, influencing both the star and its disk. In addition, the ENYGMA large program (PI: A. Maury, L. Testi) addresses unprecedented constraints on dust properties and processes at work for its evolution, using the first NOEMA dust polarization observations of embedded 52 protostars resolving down to envelope scales (~1000au). In this talk, I will present our recent progress of ALMA polarization and NIKA2 observations from the PEBBLES project and NOEMA polarization observations from the ENYGMA project (Maury et al., in prep).

First, I will present our ALMA polarization program towards unique Class 0/I protostellar twins embedded within B213 in Taurus, IRAS 04166+2706 (hereafter K66) and IRAS 04169+2702 (K69) with unprecedented spatial resolutions from ~20 au to 1000 au, resolving for the first time both the protoplanetary disks and the surrounding envelopes (**Sato et al., in prep**). Our data reveals striking differences between the two sources, despite them being embedded and born in the same environment. In particular, the polarized emission of K66 likely traces both the B-fields and self-scattering around the disk, implying that dust growth occurs not in the disk but also in the inner envelopes. (Fig.1). K69 has more compact polarized emission with a low polarization fraction <3%, implying that self-scattering could be dominant at the 20au scale. In this talk, I will discuss the implications of these differences between the twins, focusing on dust evolution and the role of magnetic fields in shaping the star formation there.

I will also present preliminary results of dust properties of clumps in Perseus, including L1448C, L1448N, and L1448-2A, obtained from NIKA2 1mm and 2mm continuum data at a resolution of ~0.02 pc, resolving the molecular cloud cores (**Zuleta et al. in prep**). Fig.2 presents the decrease of alpha towards the protostellar cores in the high-density filament, which may trace a change of dust emissivity. Finally, I will briefly introduce an overview obtained from the ENYGMA data.

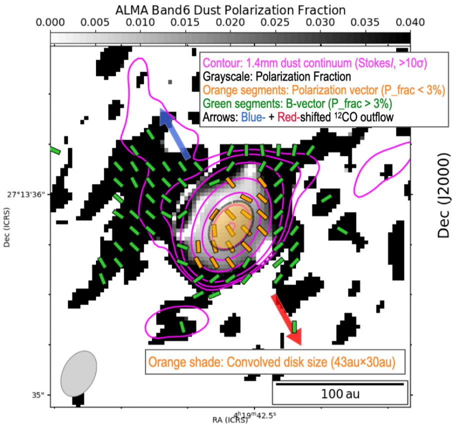

Fig.1: ALMA Band6 polarization map around a Class 0 disk of one of our targets (K66), implying that large grains may grow in the inner envelope, where the polarization fraction is lower than 3% outside the disk (Sato et al. in prep)

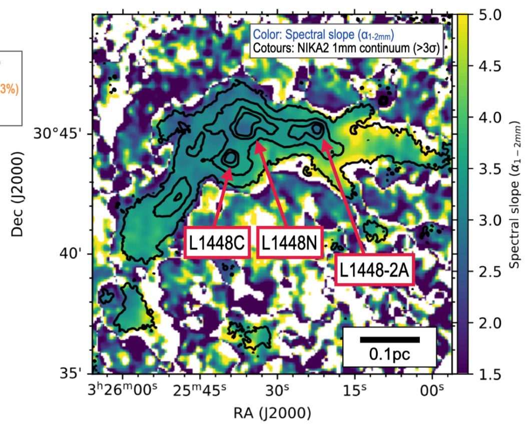

Fig.2: The preliminary map of the spectral index alpha, obtained from NIKA observations of the Perseus L1448 clump, between 1mm and 2mm. (Zuleta et al. in prep)