Title: Nautilus Multi-Grain update - How grain size distribution shapes the interstellar medium

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Abstract:
Interstellar dust grains play a pivotal role in star forming regions: they allow the formation of an ice mantle at their surface, leading to a variety of molecules from the simplest one (H_2) to the most complex organic molecules (COMs). Grains vary in sizes and composition, evolving alongside the molecular cloud up to the protostellar disk. Recent observations using the James Webb Space Telescope allowed astronomers to add constraints on the grain sizes, with distribution reaching a radius already up to 0.9 microns in early star forming regions. Usually, astrochemical models consider only one grain size for the entire population, which strongly limits the surface chemistry and the overall ice composition. In this study, we present the new version of Nautilus Multi-Grain that introduces grain size distributions in the model. We updated the chemical network, added grain radius dependent mechanisms (cosmic-ray sputtering) and new grain size distributions from dust emission models (dustEM).
The results show that the ice composition is highly impacted by the grain temperature and grain abundances, with each model its own particular molecular reservoir. We then compare the results of the gas-phase composition to millimeter data from the IRAM 30m GEMS Large Program (PI: A. Fuente) in molecular clouds and cold cores. In parallel, we check the solid phase predictions with data from the JWST ERS IceAge (PI: M. McClure) in the cold region of Chameleon II. The choice of dust models, and furthermore the grain abundances for each size, is very important to reproduce the various phases of the star formation, where bigger grains will act as COMs reservoirs and the smaller grains will rapidly enrich the gas-phase. Overall, introducing the grain distribution in astrochemical models highly improves the predicted abundances, both in gas and solid phase.