Witnessing the Formation of Stars and Planets with ALMA

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The vast number of known extrasolar planets suggests that planet formation is a natural outcome of the star formation process. During their formation, young pre-main sequence stars are generally surrounded by a gaseous accretion disk, which provides a large reservoir, up to a few percent of the total mass of the star, available for the eventual formation of planets. With the advent of sensitive observations – particularly of these circumstellar disks at radio wavelengths – and together with developments in theory, we are making rapid progress in understanding how this protoplanetary disk material is transformed into a planetary system.

In this talk, I will first describe how the evolution of protoplanetary disks is traced by observations of their solid and gas components. Next, I will present recent observational results that elucidate key aspects of the planet formation process, particularly focusing on observations at the sub-millimeter and millimeter-wave regime. Specifically, I will describe how – thanks to exceptional improvements in sensitivity and angular resolution brought forward by ALMA – we can now directly trace the signatures of planet formation around young solar analogs. These new capabilities have allowed us to test theoretical predictions for the structure of protoplanetary disks during the epoch of planet formation, to constrain the planet-forming potential in a variety of systems, and to investigate the latter stages of planet formation with observations of debris disks at radio wavelengths. Finally, I will conclude with new avenues of observational work aimed at directly witnessing the hallmarks of planet formation, particularly with ALMA and next-generation facilities.