ASTRONOMICAL EVIDENCE FOR THE RAPID GROWTH OF MILLIMETER SIZED PARTICLES IN PROTOPLANETARY DISKS.

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Background: All sun-like stars are born surrounded by disks of cool gas and dust. The presence of these disks is most readily inferred from their infrared emission but such observations only tell us about the properties of micron-sized dust grains, generally much smaller than the typical size of particles in cosmochemical studies [1]. Millimeter wavelength radio observations inform us of the distribution of millimeter-sized grains but larger objects possess a smaller area per unit mass and their emission is consequently weaker [2]. Improvements in the sensitivity of millimeter wavelength detectors allow us to carry out astronomical studies of particles in protoplanetary disks that have similar sizes to those in laboratory studies of meteorites and provide exciting possibilities for cross-disciplinary science in the near future.

Disk surveys: I present the observational results from surveys of protoplanetary disks at millimeter wavelengths with telescopes on Mauna Kea, Hawaii. The inferred distribution of disk masses and grain sizes is very similar in the ~1 Myr star forming regions, Taurus, Ophiuchus, and Orion. About 15% of disks in these regions have a minimum mass solar nebula (MMSN: 10 $M_{Jupiter}$) within 60AU radius [3,4,5]. Our most recent work on the ~2-3 Myr old region, IC348, revealed a disk mass distribution that is shifted lower by about a factor of 20, and a complete absence of MMSN disks [6].

Discussion: Although infrared observations indicate the presence of dusty disks around young stars, only optically thin, longer wavelength observations reveal their masses, and hence their capacity for forming planets. Our millimeter wavelength observations reveal a rapid decline in the amount of small dust grains but are effectively blind to particles larger than a few millimeters in size. The lack of MMSN disks in IC348 indicates either the unlikely scenario that very few planets will form in these regions or, more plausibly, that planet formation must already have progressed substantially. We conclude that most of the dust, by mass, has agglomerated into millimeter and larger sized objects by ~2-3 Myr. This agrees well with the absolute age determination of chondrules and CAIs [8].

As first science with the Atacama Large Millimeter Array (ALMA) begins later this year, we will extend our surveys to many more star forming regions across a wide range of ages and environments. This opens up the potential for a rich overlap between astronomical and cosmochemical studies of millimeter sized particles in coming years that will inform us about the first steps toward planetesimal formation.

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