

## Part II Astrophysics Essay 2021

### Detecting planetary building blocks: how observations at millimetre wavelengths can constrain solid material in protoplanetary discs

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Many planets (including our own) are predominantly composed of rocky material which ultimately derives from dust formed in stellar envelopes. Yet the interstellar medium only contains dust at the level of 1% by mass. Clearly there are processes occurring within the discs that exist around stars in the first few million years of their lives that concentrate rocky material, allowing dust to grow from the sub-micron scales on which it is found in the interstellar medium to form a wide range of macroscopic rocky bodies. Observations of protoplanetary discs provide constraints on both the rates and spatial locations of this ongoing processes.

In this essay you should consider what are the factors that make observations at around 1mm particularly useful for probing the quantity and nature of dust in protoplanetary discs. It will be necessary to discuss the theory relating continuum emission at such wavelengths to the size and morphology of dust grains and to explain how the wavelength dependence of the disc luminosity in this part of the spectrum can be used to constrain the dominant sizes of dust grains in the disc. In particular, observations can in principle distinguish between the very small dust grains inherited from the star's natal cloud to larger, mm scale grains (or cm scale 'pebbles') and you should explain how, in distinguishing these cases, it is possible to understand the relationship between dust and gas dynamics in the disc. You should also explain how observations at mm wavelengths can be used in order to estimate the total mass contained in dust and discuss the extent to which this constrains the total mass of gas in the disc.

Finally, you should consider how advances in observing capability have transformed this field in recent years and what avenues are likely to be particularly fruitful in the future. Among the issues that you might wish to consider are advances in spatial resolution, the extension of sensitive observations to longer, cm wavelength observations and the information to be gained from polarimetric observations at mm wavelengths. While the essay should mainly focus on the derivation of information about the dust from observations, you may also want to touch on how high resolution imaging of the dust component can also yield information about planets that have already formed in discs.

#### References:

- Andrews, S, et al 2018. ApJ 869,L41 (and succeeding papers in DSHARP series)  
Kataoka, A., 2017. ApJ 844,L4  
Najita, J., Kenyon, S., 2014. MNRAS 445,3315  
Testi, L. et al, 2014 in Protostars & Planets IV, eds Beuther et al, University of Arizona Press, p339 (arXiv:1402.1354)  
Tazzari, M. et al, 2016. A&A 588,A53