MODELLING THE RELATIONS BETWEEN 2D AND 3D SIZE-FREQUENCY DISTRIBUTIONS OF CHONDRULES

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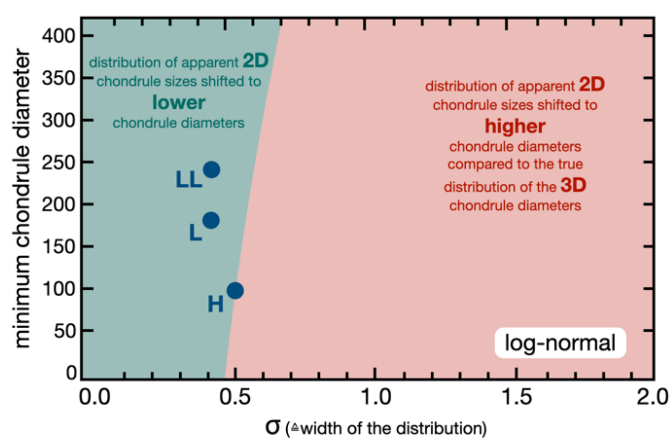
Introduction: Determining true (3D) chondrule size distributions is a long-standing problem [e.g., 1]. Determining chondrule size distributions from 3D tomography [e.g., 2-5] is tedious and time consuming, therefore, chondrule size distributions are often determined in 2D sections [6, and references therein], from so-called "apparent chondrule sizes". This is accompanied by two main sectioning effects: (i) larger chondrules are sectioned more often than smaller chondrules, biasing the result towards larger chondrule sections, and (ii) non-equatorial sections are overwhelmingly more frequent, biasing the result towards smaller chondrule sections [7]. The theoretical studies by [7,8] conclude that 2D studies overestimate large chondrules, i.e., a determined 2D chondrule size distribution should be shifted to larger chondrule sizes than the real 3D chondrule size distribution. This is contradicted by empirical studies of [1,5,9], who found the opposite: the 2D size distribution is shifted to smaller chondrule sizes compared to the determined 3D data. An attempt to apply the 2D-3D conversion of [7] to measured 2D size distributions failed [10].

Results & Discussion: We use a new mathematical model to answer the question whether the size distribution of the 2D chondrule cut faces is shifted to lower or higher values compared to the given true size distribution of the 3D chondrules. Interestingly, the answer is equivocal and depends on the parameters for the given, true 3D chondrule size distribution. This means, the size distribution of the 2D cut faces can be shifted to lower or higher values compared to the 3D distribution. Two parameters largely decide which way the 2D size distribution will be shifted: (i) the parameter for the variance of the distribution (e.g., σ) and (ii) the minimum chondrule size.

Log-normal distributions provide good fits to empirical data [1] and are therefore the ones discussed here. In the figure, the colours indicate whether the size distribution of the 2D apparent chondrule sizes is shifted to lower (teal) or higher (rose) values, depending on the combination of σ and the minimum chondrule size. Distributions of 2D apparent chondrule sizes are shifted to smaller diameters compared to the true 3D chondrule size distributions when σ and minimum chondrule sizes are small. This is reversed when σ becomes larger than at least about 0.5, depending on the minimum chondrule size of the true 3D chondrules.

The parameter σ represents the width of the log-normal distribution. At small σ ($< \sim 0.5$-0.7), chondrule sizes are rather similar. In these cases, random sections through the spheres would mostly be smaller than the true 3D chondrule sizes, and the size distribution of apparent 2D chondrule sizes would be shifted to smaller sizes. With increasing σ, larger chondrules are sectioned more often than smaller chondrules. This produces an overabundance of large chondrule sections in the distributions of the apparent 2D chondrules, which are then shifted to larger sizes compared to the true distribution of the 3D chondrule sizes.

Conclusions: We suggest that the reported contradictions between theoretical considerations and empirical data are related to the parameters used for model distributions of chondrule sizes. It is observed that the distributions of the apparent 2D sizes of real chondrules in thin sections are shifted to smaller sizes compared to the distributions of true 3D size distributions obtained by chondrule separation and µ-CT measurements [1,5,9]. These findings are confirmed by the presented theoretical considerations (Fig. 2), using realistic parameters for σ (0.45-0.5) and minimum chondrule sizes from ordinary chondrites (90-240 µm; [1]). The contradictory calculations and models [7,8] which predict the opposite likely assumed too large e.g., σ. Obviously, the solar nebula processes responsible for the observed chondrule size distributions did not allow such large values for the distribution´s variances.



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