GROWTH, FRAGMENTATION AND INWARD DRIFT OF DUST IN PROTOPLANETARY DISKS: IMPLICATIONS FOR CHONDRITIC COMPONENTS. T. Fukui and K. Kuramoto. Department of Cosmosciences, Hokkaido University, Sapporo 060–0810, Japan. E-mail: ftakashi@ep.sci.hokudai.ac.jp

Introduction: The study of dust evolution in protoplanetary disks is crucial for understanding the textual, chemical and isotopic properties of chondrites. It is widely accepted that chondrules were formed by melting of precursor dust grains in the solar nebula. Thus the typical size of chondrules would be correlated with the dust growth process. In addition, once dust grains have grown to ~ mm in size, they are subject to inward drift relative to the nebula gas. This leads to the temporal and spatial variation of the local dust-to-gas ratio, which may be responsible for the chemical and isotopic diversities observed in the chondritic components.

Model: In this study, we investigate the evolution of the spatial distribution of dust and gas in a protoplanetary disk considering the effect of dust growth. The inward drift velocity of dust can be calculated if the dust size is known. Instead of direct simulation of the coagulation equation, we develop an analytical model for the size evolution of the typical dust grains. We also include the effect of collisional fragmentation in a simple manner; i.e., dust growth stops when the mutual collision velocity, which is an increasing function of the dust size, exceeds a threshold inferred from laboratory experiments (~ a few m s⁻¹) [1].

Result: The typical result of our simulation is summarized as follows. Initially, dust grains are so small that they grow moving tightly coupled to gas. In the outer region of the disk, dust grains reaches to sub-mm in size after several 10⁵ yr and then begin to drift inward. The growth of the dust grains also continues during inward migration but finally stops because of collisional fragmentation. The dust size at which dust fragmentation begins is ~ 1 mm in the inner region of the disk if the threshold collision velocity is ~ a few m s⁻¹. In the inner region, the inward dust mass flux increases with r. As a result, a "traffic jam" of dust occurs, increasing the local dust-to-gas ratio up to several times higher than the canonical value (~ 0.01) for a few 10⁶ yr.

Implications for Chondritic Components: The resulting dust size in the inner region is comparable to that of typical chondrules. Thus, we suggest that the typical chondrule size is determined by collisional fragmentation of their precursor dust grains. The increase of the local dust-to-gas ratio in the inner region potentially explains the distinct difference in the oxygen isotopic composition of CAIs and chondrules if H₂O ice in the nebula was ¹⁶O-poor relative to the solar composition, as pointed out by previous authors [2, 3]. We newly find that the duration of the ¹⁶O-poor environment is tightly correlated with the threshold collision velocity for fragmentation. The duration decreases with increasing the threshold because dust grains can grow larger and drift more rapid.