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Implications for silicate dust growth in the massive protostellar disk GGD27-MM1 from ALMA multi-wavelength continuum polarization observations

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Understanding the formation of terrestrial planets requires elucidating the growth of silicate dust grains, the fundamental building blocks of planet formation. However, observational constraints on silicate dust growth remain limited because typical protoplanetary disks are cold and the silicate inner regions are spatially compact. To overcome this difficulty, we focus on massive protostellar disks around luminous protostars ($L > 10^4\ L_\odot$), whose disks are expected to be composed predominantly of silicate dust. In the massive protostellar disk GGD27-MM1, ALMA Band 6 (1.14 mm) polarization observations revealed polarization vectors aligned with the disk minor axis in the southeastern part of the disk (Girart et al. 2018). If interpreted as dust self-scattering, the polarization implies the presence of dust grains grown to sizes of ~100 μm and suggests that silicate dust may grow more efficiently than icy dust (Yamamuro et al. 2023, 2025). However, because this conclusion was based on single-wavelength observations, alternative interpretations such as alignment of non-spherical grains could not be excluded.

To break this degeneracy, we conducted high-angular-resolution ALMA polarization observations in Band 4 (2.12 mm) and Band 3 (3.26 mm). We find that the polarization pattern in Bands 4 and 6 is aligned with the disk minor axis, whereas the Band 3 polarization vectors are oriented azimuthally along the disk plane. This clear wavelength dependence supports the dust self-scattering origin of the Band 6 polarization. Our results therefore indicate the presence of significantly grown silicate dust grains in GGD27-MM1 and provide strong observational evidence for grain growth up to ~100 μm in a massive protostellar disk, supporting efficient growth of silicate dust.