Detecting Dark Matter Subhalos with ALMA Observations of Gravitationally Lensed Galaxies

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One of the most intriguing puzzles of modern cosmology and astrophysics is the nature of dark matter. Numerous astronomical observations have confirmed that about 80 % of the matter content of the universe is in an unknown form which does not interact with electromagnetic waves. The existence and the properties of this mysterious form of matter are purely inferred through observations of its gravitational influence on other components of our universe.

In the past two decades, it has become clear that the structure of dark matter on small, sub-galactic scales may shed light on the particle nature of this form of matter. Mapping the structure of dark matter on such small scales, however, is only achievable through a very limited number of techniques. "Gravitational lensing" is considered to be the most promising of these methods. As the light rays of extremely distant galaxies pass through dark matter halos of intervening galaxies (lenses), they are deflected by the gravity of dark matter, resulting in distorted images of these background galaxies. It has been shown that by analyzing and modeling the distortions in the images of these galaxies in great detail, we can map the small scale distribution of dark matter which can shed light on its particle properties.

ALMA observations of gravitational lenses are particularly sensitive for detecting such minute image distortions. We are currently analyzing a number of such ALMA observations. Accurate inference of the structure of dark matter using these observations requires careful and detailed modeling of the interferometric visibilities and accounting for various forms of data corruption. Given the large size of interferometric data this analysis can be extremely computationally intensive. In this talk, I will discuss the visibility modeling technique developed for this analysis, demonstrate its application to real data, and give an overview of the simulations that are used to test the effects of various interferometric data corruptions.