Multi-thermal structures in a spicule observed with ALMA, IRIS, and AIA/SDO

*Masumi Shimojo[1], Tomoko Kawate[2], Takenori Okamoto[1], Takaaki Yokoyama[3]

1. National Astronomical Observatory of Japan, 2. Institute of Space and Astronautical Science , 3. University of Tokyo

A spicule is a key phenomenon for understanding the solar atmosphere. We succeeded in observing a large spicule with ALMA, IRIS, and AIA/SDO simultaneously, and report the details of the spicule in the paper. While an eruption of a blob-like structure shown in the 100 GHz images started just before appearing a spicule in the He II and Mg II images, a spicule seen in 100 GHz image itself began about one minute after beginning the spicule in the He II and Mg II images. The spicule in the 100 GHz images can be seen as an absorbing structure in the Fe XII images. The maximum height and width of the Mg II/He II spicule are larger than those of the 100 GHz/Fe XII spicule. The 100 GHz/Fe XII spicule is included in the Mg II/He II spicule and is located at the southern edge of the Mg II/He II spicule. The rising velocities of the spicule in the Mg II and He II image, and the erupted blob in the 100 GHz images are ~70 km/s. On the other hand, the rising velocity of the spicule in the 100 GHz and Fe XII images is ~40 km/s. Considering of the differences of the structures shown in the Mg II/He II and 100 GHz/Fe XII images, and the typical formation temperature of each band, the 100 GHz and Fe XII images show a cold and dense component of the spicule. The conclusion is consistent with the recently radiative MHD simulations, and we can explain why the 100 GHz spicule is delayed, shorter, and slower than the Mg II/He II spicule. The solar limb observations with ALMA are very few. Hence, it would be not accidentally that the blob-like eruptions are associated with both two large spicules observed with ALMA. The fact might suggest that large spicules included a cold and dense component is produced by magnetic reconnection that is induced by a plasmoid eruption, like a corona jet.

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