ALMA-Hinode-IRIS coordinated observations of solar nanoflares in cycle 4

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Solar observations have started by ALMA from cycle 4 period (October 2016 - September 2017). For this period, a lot of projects for solar observations were proposed to ALMA, which accepted 15 solar projects. Of which, the project led by the authors (2016.1.00030.S) is to carry out the energy evaluation of micro- and nano-flaring heating events in solar active regions. Magnetic reconnection events in nanoflare energy range are a candidate for the heating of the corona in active regions. The number distribution of reconnection events as a function of energy is essential to evaluate the importance of nanoflares in the heating. ALMA observations would provide a new capability for newly exploring the released energy of reconnection events in the energy range around 10^(22)-10^(24) ergs. Transient heating of the plasma at the upper chromosphere, caused by reconnection events, should be observed as the transient increase in brightness temperature. The time series of the ALMA measurements, coordinated with Hinode and IRIS observations, are investigated to establish a new method for estimating the amount of the energy released by each of small reconnection events.
The observation for this project was executed in March 19, 2017, successfully coordinated with observations by space-borne Hinode and IRIS. The ALMA antenna configuration was C40-1 with compact baseline lengths of 15-155 m, providing a beam size of 3.7 arcsec. An ephemeral active region on the solar disk, which was the only bright region because of extremely low solar activity condition, was the target and the time series of band 3 (100GHz) map data was obtained for about 3 hours in total. The verification of the co-alignment among ALMA, Hinode, and IRIS data was the first challenging step in the data analysis, but owing to efforts on verification of the solar coordination, we finally confirmed the reliable co-alignement. Microflares did not take place in the field of view during the observation, but we found a lot of smaller increases in ALMA temperature map. The largest one is in order of 30 K, which is sufficiently above the noise level (10K). It was located at the magnetic polarity inversion line where a positive magnetic polarity island is located next to a negative island. Smaller ALMA temperature increases are observed at the area beside magnetic islands, rather than inside the islands. The spatial size of temperature increase events is similar to the beam size. Assuming that the temperature increase is due to energy input to the upper chromosphere, the observed temperature increase may correspond to the energy input in order of 10^22 erg. Moreover, we also found a part of temperature increase shows periodic changes, which may suggest compressional waves. In this talk, we present an initial result from our ALMA-Hinode-IRIS observation and discuss the energy evaluation of solar nanoflares and the signature of waves.

Keywords: The Sun, Nanoflare, Coronal heating

