Microwave bursts during solar flares carry information of both nonthermal electron acceleration and thermal heating, and separation of these two components has been one of the major issues in solar flare study. In this work, we tested a new method for determining thermal and nonthermal components without hard X-ray imaging spectroscopy. This method employs the coronal emission measure (EM) from SDO/AIA and the high sensitivity, high fidelity microwave maps from the Nobeyama Radiopheliograph (NoRH). The idea is to calculate the contribution of free-free intensity with knowledge of the EM and electron temperature from the SDO/AIA, and subtract it from the observed flux to determine the nonthermal component.

At 01:36 UT (the left column), the NoRH source is a single compact source located above the magnetic polarization inversion line (PIL) of the eastern bipolar spot. Thermal emission, although present, is so much weaker that the difference intensity is not significantly different from the observed flux. The 17 GHz emission is thus dominated by nonthermal gyrosynchrotron emission. At 02:05 UT (the middle column), the subtracted image (red contours) does not look very different from the observed one (black contours), but has two sources across the PIL more clearly distinguishable, which is more like a two-ribbon structure in the standard flare model. There is another component extruding from the PIL to the northwest that is bright in the AIA 171 A image (top panel) but dim in the 17 GHz image (bottom), implying that it is a thermal source. At 02:30 UT (the right column), another radio source suddenly appears in the region close to the western spot, where previously no strong EUV or 17 GHz emission was present. Since the region is void of AIA EM, we regard this 17 GHz source as an almost entirely nonthermal source (red contours in the west). In contrast, the main source over the bipolar spot was initially nonthermal and becomes a mixture of thermal plus nonthermal sources by this time while the northwestern source is always a thermal source.

The flux and EM in the latter two sources are an order of magnitude weaker than those in the main source above the bipolar spot, and could nevertheless be detected thanks to the high sensitivity of the NoRH to energetic electrons. This demonstrates how the combination of SDO/AIA and NoRH observation can help understanding the nonthermal particle acceleration and thermal heating in solar flares.

This work was carried out under the joint research program of the Institute for Space-Earth Environmental Research, Nagoya University.