Discovery of long-sought tiny explosions that super-heat the sun's corona

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One of the telescopes of the MWA which was used to gather the data used for this study. The MWA has 128 such telescopes, referred to as tiles, distributed over about 5 km diameter. Credit: Pete Wheeler/ICRAR

The sun is the brightest object in the sky and has been studied for hundreds of years, but it continues to hide some secrets. The visible sun is extremely hot, at a temperature of about 5500 degrees. Surprisingly, on top of this sits a layer of gas, called the corona, which has a temperature of almost 2 million degrees, over 300 times hotter than the actual surface of the sun. What heats up the corona to 2 million degrees has been an enduring mystery with no satisfactory answer.

One efficient way of extracting this energy from the magnetic fields involves numerous tiny explosions constantly taking place all over the sun. Individually, these explosions are weak, but collectively, they have sufficient energy to heat the entire corona due to sheer numbers. Many attempts have been made to find X-rays and ultraviolet light emitted by these explosions, but none has been successful. Researchers concluded that if they exist, these tiny explosions are too weak to be detected by even the best instruments available today. The explosions are also expected to give rise to tiny flashes of radio light, but until now, there were no telescopes sensitive enough to detect them.

Now, a group of scientists working at the National Centre for Radio Astrophysics (NCRA), a part of the Tata Institute of Fundamental Research, has reported the discovery of tiny flashes of radio light originating all over the sun. They have identified these as the smoking guns for small magnetic explosions. This comprises the first-ever evidence for their existence, and can potentially explain the long-

standing coronal heating problem. This work was led by Surajit Mondal, under the supervision of Prof. Divya Oberoi, Dr. Atul Mohan, formerly at NCRA, and now at the Rosseland Centre for Solar Physics, Norway. In their journey to unravel this mystery, the scientists have already figured out that the extra energy heating up the corona must be coming from the solar magnetic fields, but exactly how this happens is still not known.

"What made this breakthrough possible," said Prof. Divya Oberoi, "is the availability of data from a new instrument, the Murchison Widefield Array (MWA), and the work which we have been doing for the past few years at NCRA-TIFR to build the techniques and tools to make the most sensitive solar radio images from this data. The very weak radio flashes we have discovered are about 100 times weaker than the weakest bursts reported until now."

Surajit Mondal, the lead author of the study, said, "What makes this really exciting is that these flashes are present everywhere on the sun, and at all times, including in the regions of weak magnetic fields, the so-called 'quiet sun' regions."

Dr. Atul Mohan said, "Our preliminary estimates suggest that these tiny magnetic explosions should collectively have enough energy to heat the corona, which is exactly what is needed for solving the coronal heating problem."

More information: Surajit Mondal et al, First Radio Evidence for Impulsive Heating Contribution to the Quiet Solar Corona, *The Astrophysical Journal* (2020). DOI: 10.3847/2041-8213/ab8817

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