VLB ARRAY MEMO No. 260

Possible Solar Observations with the VLBA

by

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The emission of short duration ($\lesssim$ 0.02 s), high brightness temperature (~ 10^{15} K) spikes at microwave frequencies (~ 3 GHz) during the impulsive phase of some solar flares is now well established. The spikes are often almost 100% polarized. The inferred sizes of the sources of the spikes lie in the range 0.03" - 0.3", depending upon the velocity of the exciting agent; the lower value corresponds to an exciter moving at the Alfvén velocity, while the higher value corresponds to excitation by high energy particles. VLBI measurements made at 18 cm with 0.2 sec time resolution indicates the presence of a $\gtrsim 10^{12}$ K source at 18 cm-λ with an angular size $\lesssim$ 0".07[1]. The high brightness temperatures deduced for the spikes indicate that a coherent radiation mechanism must be responsible.

There are at present three coherent mechanisms proposed for the spike emission: (1) gyrosynchrotron masering from mildly relativistic electrons mirrored in the flaring magnetic loop[2,3,4]; (2) plasma radiation at twice the upper hybrid frequency ($\omega_{UH}^2 = \Omega_e^2 + \omega_e^2$)[5]; and (3) plasma radiation at the electron plasma frequency (ω_e) or at $2\omega_e$[6]. Gyrosynchrotron masering is expected to be observed from one or both legs of a flaring loop, since the emission is produced by the loss-cone electron distribution that forms immediately after the particles are mirrored by the stronger magnetic field in the lower part of the loop. The upper hybrid waves and the Langmuir waves required by the other two mechanisms are generated by an unstable distribution of streaming suprathermal electrons and, therefore, may be produced in any part of the loop. If the electrons are accelerated at the top of the loop, as is often believed to be the case, the coherent microwave radiation from upper hybrid or Langmuir waves may be observed from the top of the loop. Emission at ω_e requires a (rather high) plasma density of 10^{11} cm^{-3} (2×10^{10} cm^{-3} if the emission is at $2\omega_e$), however, which is most likely to be found in the lower part of a cornal loop or in a small, low-lying loop.

To test the validity of these diverse models, it is important to map the masering microwave burst sources with time resolution ~ 1 ms, and compare their positions with simultaneous VLA maps of the entire microwave loop representing background smooth emission produced by energetic electrons by gyro-synchrotron process. The synthesized maps produced with integration times of 1-10 ms should be made only for short periods (a few seconds at a time) when appropriate. Obviously the VLBA in the pulsar mode will be an ideal instrument to do this. There must be some alert system established to minimize the waste of time and tape.

References

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