SOLAR BURSTS OBSERVED WITH THE NEW SOLAR SUBMILLIMETER-W TELESCOPE

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ABSTRACT

The new solar dedicated submillimeter wave telescope built at El Leoncito in the Argentina Andes has a radome-enclosed 1.5-m Cassegrain antenna with focal plane arrays of two 405 GHz and four 212 GHz radiometers operating simultaneously with high time resolution. Solar flares exhibit rapid submm-w spikes (100-300 ms), which repetition rates increase with flare bulk emission intensities. The spikes positions are found displaced in space by tens of arcseconds. Coronal mass ejection (CMEs) velocities extrapolated to the solar surface appear to correspond to the onset time of the submm-wave spikes, which might represent an early signature of CMEs initial acceleration process.

SUMMARY

We describe the first results obtained with the new solar-dedicated submillimeter wave telescope, the SST project, which was installed at the Complejo Astronomico El Leoncito, in the Argentina Andes (Kaufmann et al., 2001). The SST consists in two 405 GHz and four 212 GHz total power room-temperature radiometers, which single linear polarization feed horns are placed in the focal plane of a 1.5-m cassegrain antenna. The antenna is mounted in a alt-azimuth pedestal, inside a 3-m radome. The six receivers operate simultaneously with one millisecond time resolution. The radio telescope half power beam widths of 2 arcmin at 405 GHz and 4 arcmin at 212 GHz were derived from planet observations. Three 212 GHz feed horns were assembled close together to produce partially overlapping beams at the 3dB level to allow the spatial position determination of solar burst enhancements with time, using the same concept developed for use at mm-waves (Georges et al., 1989; Gimenez de Castro et al., 1999). The correlation of solar burst transient signals by the different beams allows their spatial position determination, with high angular accuracy which depend on the knowledge of the beamshapes (provisionally restricted to less than about 10 arcseconds). One 405 GHz beam is located t the center of the 212 GHz cluster of three beams. Nearly 7 arcmin from this cluster are located the other 212 and 405 GHz beams, nearly coincident, which may be used in "beam-swithing" mode to minimize propagation variations, when all beams are on the solar disk.

The new instrument was fully tested, integrated and optimized during several campaigns in 1999-2001, and is now being operated more regularly for the present Solar Cycle maximum phase. Considerable attention is being given to the atmospheric opacity methods of determinations, with large amount of measurements made at different seasons. The sky transmission at El Leoncito was found to be excellent for the two frequencies, for the altitude SST is located (2,550 meters) (see Melo et al., 2002, in the present URSI General Assembly).

The first solar flares were observed while SST was undergoing tests and optimizations. Numerous events recorded afterwards are currently being analyzed. Results from the first analysis were reviewed elsewhere (Kaufmann, 2002). It has been found that rapid submm-w spikes (100-300 ms) are observed with flares, exhibiting rates of occurrence proportional to the main burst emission changes with time. In particular it has ben found an excellent association of gamma-ray emission time profiles to the rate of occurrence of submm-w rapid spikes. Submm-w spikes positions were found displaced over the flaring region by tens of arcseconds with respect to the position of the bulk emission source. These results suggest that the bulk burst emissions appear as a response to numerous fast energetic injections, discrete in time, at different spatial positions, quantized in energy.

For the events studied the main submm wavelength fluxes appear to reduce with frequency, as predicted for optically thin synchrotron emissions. However, the submm spikes' fluxes seem to increase with frequency in the range 200-400 GHz. Their nature raise several basic questions to be further investigated with more observations and theoretical explorations, such as: (a) have the submm-w spikes a physical nature distinct from the bulk emission?; (b) are them related to subsecond time structures observed at optical wavelengths?; (c) are them associated to rapid modulation of emission by waves and quakes?; (d) are them thermal bombs with short cooling times in a dense ambient plasma?; (e) are them non-thermal dense short-lived synchrotron sources in which inverse Compton action might be one effective loss mechanism?

Coronal mass ejections (CMEs) observed by SOHO/LASCO coronagraphs were associated to the submillimeter events studied. The CME velocities extrapolated to the solar surface appear to correspond to the onset time of the submm-wave spikes, which might represent an early signature of CMEs initial acceleration process. This suggested evidences might bring new important clues for the understanding of these highly energetic phenomena in the solar atmosphere, which are known to have a profound influence in space weather conditions.

The rebirth of solar flare observations in the submm-IR range is still at its very beginning. The results which are now being obtained are highly suggestive on how much we still have to learn in this nearly unexplored range of wavelength in order to get a better and full description of the flare process. SST is the only dedicated solar instrument available for submm observations. For the present solar cycle it should be highly desirable the use of few other existing submm-wavelength telescopes in the world - which can be pointed to the Sun if properly protected for heat damages - for flare observations. For the next solar cycle, in the time scale of 5-10 years, we may expect new steps in diagnostics from a new generation of THz ground-based telescopes, using with new technologies such as a single-dish antenna of the ALMA project, with imaging focal plane arrays of bolometers, and in space using far-IR imagers as proposed by France experiment MIRAGES (Trottet, 2001).

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