

Name of research institute or organization:

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**Institute of Applied Physics, Universität Bern**

Title of project:

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Solar Sub-Millimeter Flare Observations with KOSMA

Project leader and team

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Dr. Andreas Magun, project leader

Dr. Thomas Lüthi, Dr. Andreas Lüdi, Dr. Axel Murk

Project description:

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Solar flare emission at millimeter and submillimeter wavelengths provides important information on the acceleration process of electrons to relativistic energies and on the hot solar flare plasma. With the development of submillimeter instrumentation this radiation can be observed from high-altitude sites like Gornergrat. In collaboration with KOSMA (Köln Observatory for Submillimeter and Millimeter Astronomy) we conducted a total of six observation campaigns during periods of high solar activity.

On April 12, 2001 a solar flare was observed at 230 and 345 GHz, for the first time at submillimeter wavelengths. An analysis combining these submillimeter observations with centimeter-millimeter observations from the solar observatories at Bumishus and Bern, as well as soft and hard X-ray data from the GOES and Yohkoh spacecrafts was published in *Astron. & Astrophys.* [1].

Besides spectral development, also the location and diameter of the radio flare sources provide important clues for the acceleration process. Therefore a novel 210 GHz multibeam receiver was developed. It consists of three radiometers, with a fourth beam synthesized from the other three. The four intersecting beams allow measurement of source locations with arc-second angular and millisecond temporal resolution and, for the first time, also the determination of the effective source size at short millimeter waves. Beam splitting of the received signal allows simultaneous observations with the original 230/345 GHz system of KOSMA in order to obtain spectral information. The quasioptical setup of the new receiver as well as numerical simulations and measurements of the relevant focal plane and antenna patterns were presented in a conference paper [3]. During the period of exceptionally high solar activity in October/November 2003, four events have been observed. One of them, the giant GOES X17.2 flare on October 28, 2003, exhibited a complex temporal evolution of the millimeter flux, a significant shift of the source position, correlated with a dramatic change in source diameter. Surprisingly, we found rising spectra between 210 and 345 GHz during the long-lasting decay phase. These findings, as well as the numerical method for the determination of the source flux density, position and effective source size, have been published in *Astron. & Astrophys.* [3].

These submillimeter observations of solar flares are in great demand and several international collaborations for their detailed information have been started, including groups from the observatory of Paris/Meudon, France and the Universidade Presbiteriana Mackenzie, Sao Paulo, Brazil. First results have been presented at the CESRA Workshop 2004 in Sabhal Mòr Ostaig, Isle of Skye [4], and at the 35th COSPAR scientific assembly in Paris [5,6].

The instrumental aspects of these observations as well as their analysis and interpretation are also the main subjects of a PhD thesis [7].

Key words:

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Sun, flare, millimeter/sub-millimeter emission

Collaborating partners/networks:

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I. Physik. Institut, University of Cologne, Cologne, Germany  
LESIA Observatoire de Paris, Meudon, France  
CRAAM Universidade Presbiteriana Mackenzie, Sao Paolo, Brazil

Scientific publications and public outreach 2004:

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**Refereed journal articles**

[1] Th. Lüthi, A. Magun and M. Miller, First observation of a solar X-class flare in the submillimeter range with KOSMA, *Astron. & Astrophys.*, vol.: 415, no.: 3, pp.: 1123-1132, doi: 10.1051/0004-6361:20034624, 2004.

[2] Th. Lüthi, A. Lüdi and A. Magun, Determination of the location and effective angular size of solar flares with a 210 GHz multibeam radiometer, *Astron. & Astrophys.*, vol.: 420, pp.: 361-370, doi: 10.1051/0004-6361:20035899, 2004.

**Conference papers**

[3] T. Lüthi, A. Murk, A. Magun, A. Lüdi and V. Vasic, A Multibeam Instrument for Solar Flare Observations at Millimeter Wavelengths Quasioptical Design and First Antenna Pattern Measurements, The 28th International Conference on Infrared and Millimeter Waves, ed.: N. Hiromoto, pp.: 219-220, 2003.

**Conference talks**

[4] Th. Lüthi, First measurements of the effective angular size of solar flares at 210 GHz, CESRA Workshop 2004 The high energy solar corona: waves, eruptions, particles, Sabhal Mòr Ostaig, Isle of Skye, 11.06.2004.

[5] G. Trottet, Th. Lüthi, N. Myagkova, C. Dauphin, A. Magun, N. Vilmer, S. N. Kuznetsov, B. Y. Yushkov, K. Kudela, Centimeter/submillimeter and hard X-ray/gamma-ray observations of the GOES X12.7 Flare on 2003 October 28, 35th COSPAR scientific assembly, Paris, 23.07.2004.

**Conference poster**

[6] J.-P. Raulin, Th. Lüthi, G. Trottet, E. Correia, Meter to submillimeter observations of a small flare in the decay of the GOES X12.7 flare on 2003 October 28, 35th COSPAR scientific assembly, Paris, 18.-25.07.2004.

**Theses**

[7] Th. Lüthi, Solar Flares at Millimeter and Submillimeter Wavelengths – Instrumental Techniques and Observations, Philosophisch-Naturwissenschaftliche Fakultät, Universität Bern, 2004.

Address:

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Institut für Angewandte Physik  
Universität Bern  
Sidlerstrasse 5  
CH-3012 Bern

Contacts:

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Andreas Magun

Tel.: +41 31 631 8914

Fax: +41 31 631 3765

e-mail: [magun@mw.iap.unibe.ch](mailto:magun@mw.iap.unibe.ch)

URL: <http://www.iapmw.unibe.ch>

