Solar observations with LLAMA

Cristiani Germán^{1,2}, Mandrini Cristina Hemilse¹

 (1) Instituto de Astronomía y Física del Espacio / CONICET-UBA, Buenos Aires, Argentina
(2) Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, Departamento de Física, Buenos Aires, Argentina

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Solar flares (radio bursts)

- Energies 10²⁹ 10³² ergs
- Typical times 10² 10³ sec
- Produced by magnetic recconection

- Plasma heating
- Particle acceleration
- MHD waves
- Radiation



Sketch of a solar flare (Aschwanden & Benz, 1997)

Microwave observations

- Owens Valley Solar Array (OVSA, 1 18 GHz)
- Radio Solar Telescope Network (RSTN, 245 MHz 15.4 GHz)
- Nobeyama Radio Heliograph (NoRH, 17 and 34 GHz)
- Nobeyama Radio Polarimeter (NoRP, 1 80 GHz)
- Pierre Kaufmann Radio Observatory (AKA Itapetinga Radio Observatory, 18 - 26 GHz and 40 - 50 GHz)



Submillimeter observations

- Solar Submillimeter-wave Telescope (SST, 212 and 405 GHz)
- Kölner Observatorium für Submillimeter und Millimeter Astronomie (KOSMA, 210 and 345 GHz)





Sub-mm events exhibiting the THz component

- Free free
- Synchrotron (electrons)
- Synchrotron (positrons)
- Synchrotron (thermal)
- Cherenkov
- Microbunching
- Plasma emission
- Inverse Compton
- Diffusive radiation
- Synchrotron maser

. List of flares with a rising spectrum of sub-THz emission.

Solar flare (GOES class)	Sub-THz (UT)	δ	F. density (sfu)	
SOL2000-03-22T18:48 (X1.1) ^a	18:50:00	$1.27^{+0.63}_{-0.63}$	500	
SOL2001-04-12T10:28 (X2.0)b	10:17:54	$1.09^{+0.96}_{-1.07}$	810^{\dagger}	
SOL2003-10-27T12:43 (M6.7) ^c	12:32:30	$1.68^{+0.48}_{-0.49}$	86^{\dagger}	
SOL2003-10-28T11:10 (X17)d	11:16:12	$2.0^{+0.8}_{-0.53}$	4500 [†]	
SOL2003-11-02T17:25 (X8.3)e	17:19:30	$3.41^{+2.92}_{-1.79}$	50 000	
SOL2003-11-04T19:50 (X28)f	19:44:00	$0.71^{+0.23}_{-0.24}$	18 000	
SOL2006-12-06T18:47 (X6.5)g	18:43:51	$0.98^{+0.68}_{-0.93}$	6800	
SOL2012-10-22T18:51 (M5.0) ^h	18:48:30	$1.42^{+0.48}_{-0.49}$	50	
SOL2012-07-04T09:55 (M5.3) ^{i‡}	09:55:30	$1.29^{+0.6}_{-0.63}$	39 [‡]	١
SOL2012-07-05T11:44 (M6.1) ^{j‡}	11:44:24	$1.33^{+0.6}_{-0.63}$	26 [‡]	
SOL2013-02-17T15:50 (M1.9)h	15:46:25	$1.42^{+0.28}_{-0.28}$	200	
SOL2014-10-27T14:47 (X2.0)h	14:22:50	$1.07^{+0.31}_{-0.31}$	60	
SOL2014-11-05T19:44 (M2.9)h	19:53:40	$0.63^{+0.4}_{-0.38}$	30	
SOL2014-11-07T17:26 (X1.6)h	17:25:30	$0.52^{+0.29}_{-0.29}$	70	

Kontar et al., 2018.

Sub-THz radio data are from the following papers: ^(a) Kaufmann et al., 2001; Trottet et al., 2002; ^(b) Lüthi et al., 2004a; ^(c) Trottet et al., 2011; ^(d) Lüthi et al., 2004b; Trottet et al., 2008; ^(e) Silva et al., 2007; Kaufmann et al., 2009a; ^(f) Kaufmann et al., 2004 and 2009b, ^(g) Kaufmann et al., 200b; ^(f) Fernandes et al., 2017; ^(f) Tsap et al., 2016; ^(f) Tsap et al., 2018.

Kaufmann & Raulin (2006), Kaufmann et al. (2009), Krucker et al. (2013), Kontar et al. (2018)

Future LLAMA Observations – Flares

Difficulties

- Lack of a multibeam system
- Small beam sizes at higher frequencies

Possible solutions

- Phase 1: Determination of the source location
 - Complimentary instrument (flare finder)
 - Fast scans

Phase 2: Observations with on-the-fly mapping

- OTF map of $2' \times 2' \longrightarrow 12$ sec
- OTF map of $3' \times 3' \longrightarrow 20$ sec

Future LLAMA Observations – quiet Sun

Daily mapping:

- Solar radius determination: $R(\nu)$
- Limb brightening intensity observation

Analysis:

- Input for atmospheric models
- Correlation with the level of activity (Selhorst et al., 2011)

Acknowledgement & Poster

Thanks a lot!

SOLAR OBSERVATIONS WITH LLAMA Cristiani Gernala¹², Mandetai Cristian Benalle¹

(1) Instituto de Antonomía y Fósia del Espacio / CONEXET-UDA, Barnos Alees, Argentina (2) Universidad de Barnos Alees, Facultad de Consine Exactae y Naturales, Departamento de Física, Barnos Alees, Argent

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taken for the commit parameters and/or result with its with observations at other spectral ranges and/or are insufficiently studied mechanisms.

Future Observations with LLAMA

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Once the location of the flare is determined the automas can do on-the-fly maps around the flare position. A $Z \times Z$ map can be obtained in around 20 accords for flared 9, which has the modest beam with BPRES 10^o

Indeter first analysis, and water to implement, ILAMA spirit for also observations are provide a large mature of data valued to the structure of the webst atmosphere. Solar adfau determine final is function of foreparing it as mesoary input for dimensionimetry on the structure and main brightening can be surred out to support or indicate provision websits the correlated integration being the structure provision websits the transition of the SO(1). **References**

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SCHOOL WITH LEAVIN

