INSTITUTET FÖR RYMDFYSIK

Swedish Institute of Space Physics

An MMS bow shock database using machine learning: EU H2020 SHARP project

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SHARP

VGEM 2021

SHARP

SHocks: structure, AcceleRation, dissiPation

In collaboration with FMI, IRF, UvA, UCLA College | Physical Sciences Earth, Planetary & Space Sciences

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SHARP (SHocks: structure, AcceleRation, dissiPation) project is funded by the European Union's Horizon 2020 research and innovation programme. It started on January 1st, 2021 and will run for 3 years. The project is aimed at achieving a breakthrough in our understanding of collisionless shocks on the basis of comprehensive data analysis. SHARP project is consolidating efforts of the world-leading experts in Europe *(Finnish Meteorological Institute, Finland; Swedish Institute of Space Physics, Sweden; Universiteit van Amsterdam, Netherlands)*, Israel *(Ben-Gurion University of the Negev)* and USA *(University Of California, Los Angeles)*. The project will result in a set of freely accessible, higher-level data products to aid the identification of events and fast determination of the shock parameters.

Collisionless shocks are one of the most fundamental phenomena in space and one of the most powerful accelerators in the universe. Despite more than half a century of collisionless shock research, our understanding of the processes of the shock energy dissipation into charged particle heating and acceleration remains incomplete.

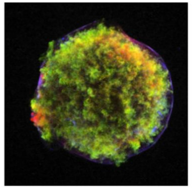
SHARP will achieve a major leap in the understanding of the structure of collisionless shocks in various environments and of the acceleration processes at all shock scales. This will be done by:

a) intensifying exploitation of the heliospheric data and performing a thorough and comparative analysis of the Earth bow shock, planetary shocks, and interplanetary shocks,

b) establishing a collaboration of world-renown groups to significantly advance knowledge in all aspects of the shock physics,

c) utilizing and combining the knowledge obtained from in situ measurements of heliospheric shocks and remote observations of distant astrophysical shocks, and

d) developing an open-source high-level database of shocks and a centralized source of advanced tools for the purpose of analysing shock structure and dynamics.



Tycho supernova remnant processed from NASA Chandra X-ray observatory data. Provided by J. Vink (University of Amsterdam).

Search …

NEWS

New publication: "Shock Heating of Directly Transmitted Ions" by Michael Gedalin June 24, 2021 - Observations in the heliosphere show that magnetized collisionless shocks are very efficient at ion heating. Ion heating is a nonadiabatic process and the temperature downstream of the shock is not proportional to the upstream temperature. Directly transmitted ions may be responsible for most of the downstream temperature. We determine the gyrophase-dependent distribution of directly transmitted … Continue reading

SHARP Progress meeting February 23, 2021 - The first SHARP Progress meeting took place on 23rd of February, 2021.

Site under construction February 9, 2021 - The SHARP project web page is currently under construction. More information coming soon.

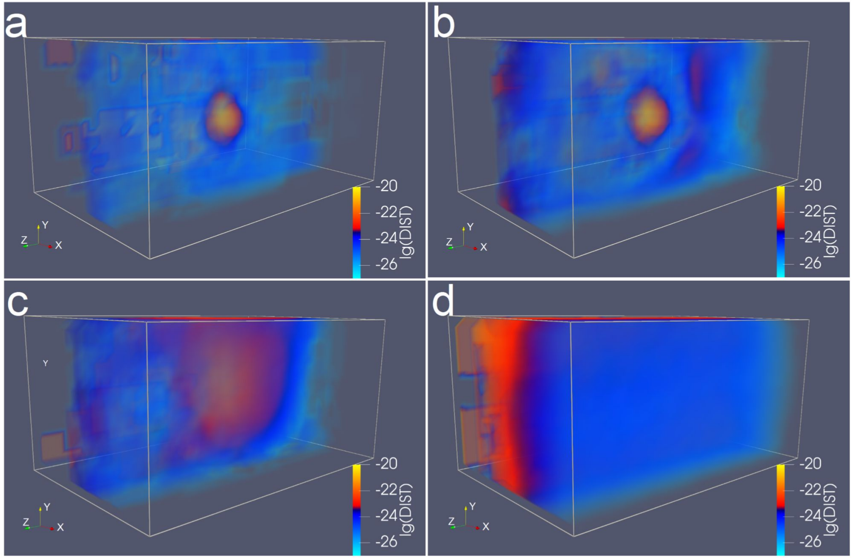
SHARP Kick-off meeting January 8, 2021 - The SHARP Kick-off meeting took place on January 7th and 8th, 2021.

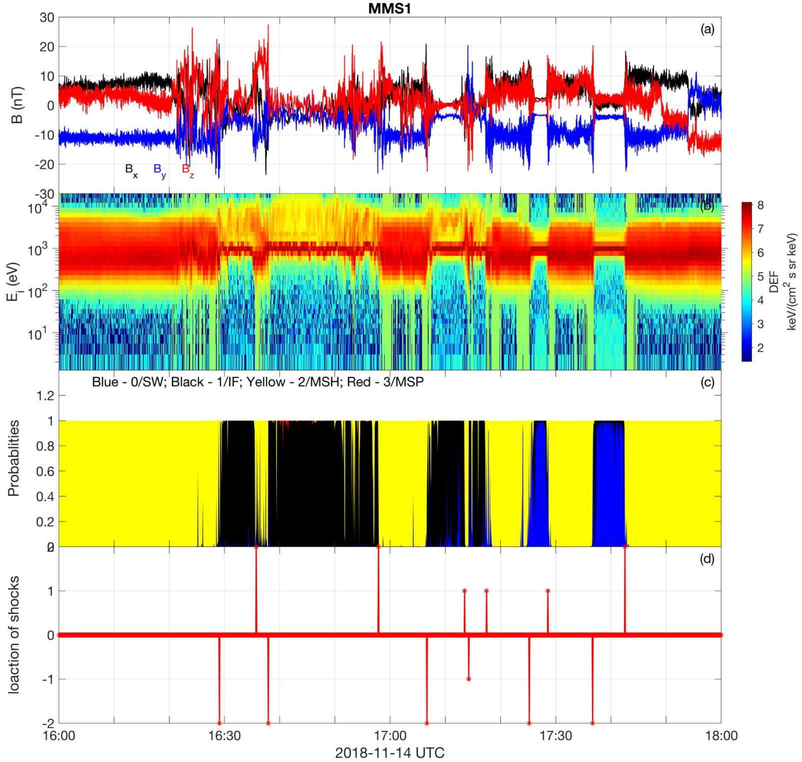
EXTERNAL LINKS

SHARP on Zenodo

https://sharp.fmi.fi

Identification of shocks (Olshevsky+, 2021)

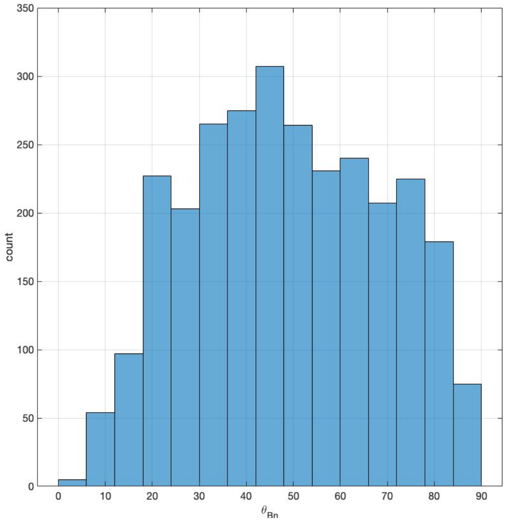


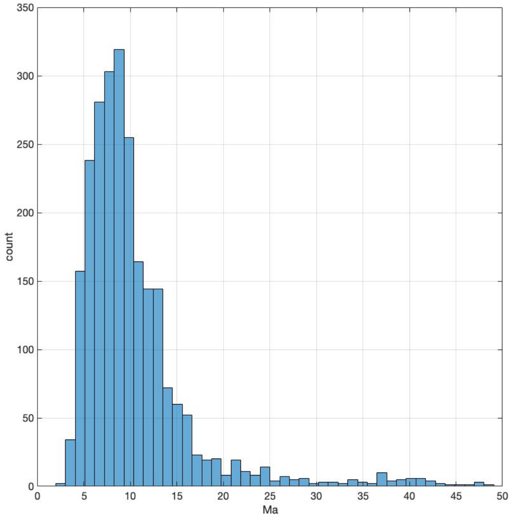


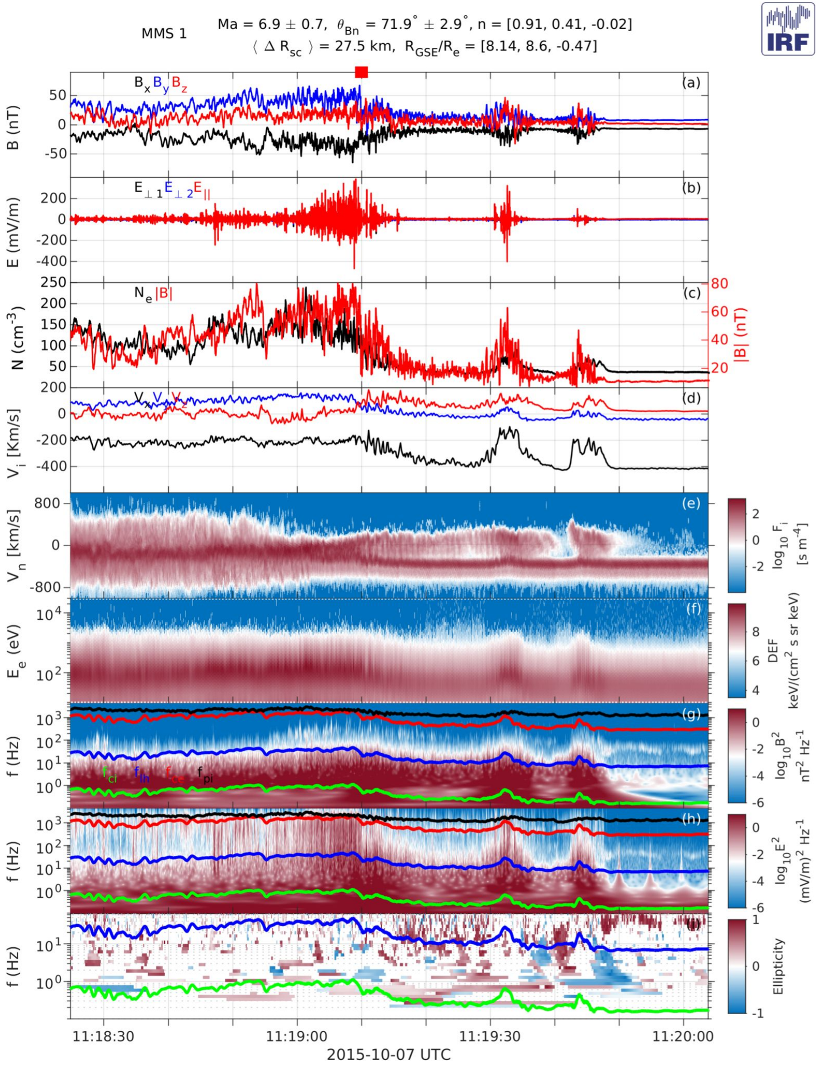
Olshevsky+, JGR, 2021 https://arxiv.org/abs/1908.05715

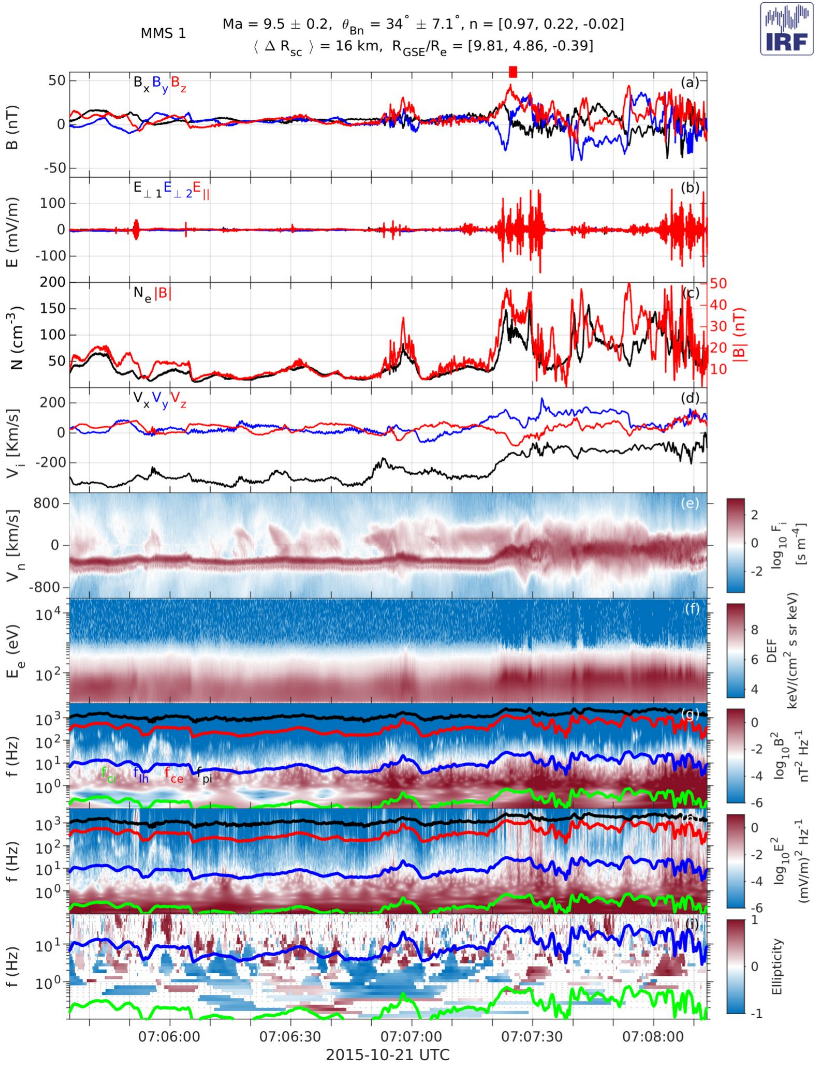
MMS shock database

- Currently we have >3000 shocks in the database (2015-2020)
- Mixture of geometries
- Interesting shocks with high Mach numbers
- We are currently working on checking the entries and validating the parameters (also removing false events)
- Currently we use OMNI to calculate Mach number and geometry but we are looking into using the local MMS measurements and introducing quality flags/indicators






MMS 1
Ma = 6.9 ± 0.7, θBn = 71.9° ± 2.9°, n = [0.91, 0.41, -0.02]
⟨ Δ Rsc ⟩ = 27.5 km, RGSE/Re = [8.14, 8.6, -0.47]
B (nT)
E (mV/m)
N (cm-3)
|B| (nT)
Vi [Km/s]
Vn [km/s]
Ee (eV)
f (Hz)
log10 Fi [s m-4]
DEF keV/(cm2 s sr keV)
log10 B2 nT2 Hz-1
log10 E2 (mV/m)2 Hz-1
Ellipticity
11:18:30
11:19:00
11:19:30
11:20:00
2015-10-07 UTC


MMS 1
Ma = 9.5 ± 0.2, θBn = 34° ± 7.1°, n = [0.97, 0.22, -0.02]
⟨ Δ Rsc ⟩ = 16 km, RGSE/Re = [9.81, 4.86, -0.39]
B (nT)
E (mV/m)
N (cm-3)
|B| (nT)
Vi [Km/s]
Vn [km/s]
Ee (eV)
f (Hz)
log10 Fi [s m-4]
DEF keV/(cm2 s sr keV)
log10 B2 nT2 Hz-1
log10 E2 (mV/m)2 Hz-1
Ellipticity
07:06:00
07:06:30
07:07:00
07:07:30
07:08:00
2015-10-21 UTC

Interface

Shock database selection

Build your shock database.
To receive all available data, click 'Submit' without selecting anything.
To limit and specialise your database, select any spacecraft or mission, and/or adjust any parameter range, before clicking 'Submit'.

Observing spacecraft(s):
☐ MMS 1 ☐ MMS 2 ☐ MMS 3 ☐ MMS 4 [Select all MMS]
☐ Cluster 1 ☐ Cluster 2 ☐ Cluster 3 ☐ Cluster 4 [Select all Cluster] (Cluster observations cover the period 27 Jan 2003 - 16 Dec 2012)
☐ THEMIS A ☐ THEMIS B ☐ THEMIS C ☐ THEMIS D ☐ THEMIS E [Select all THEMIS]
[Clear all] (If all spacecraft and mission boxes are left empty, then everything will be included.)

Shock type: ☐ Bow shocks ☐ Interplanetary shocks (If left empty, all will be included.)

Data mode: ☐ Burst ☐ Fast (If left empty, all will be included.)

Adjust one or more parameter ranges:
(The pre-filled default values correspond to the lowest and highest values in the current database.)

		Lower limit		Upper limit	
	Date / time range	27/01/2003 00:00		16/12/2012 23:59	
	Separation between observations of same constellation ○ min ○ mean ◉ max	120	km	17162	km
V_{us}	Plasma velocity magnitude upstream of the shock	270	km/s	930	km/s
B_{us}	Magnetic field magnitude upstream of the shock	1	nT	55	nT
n_{us}	Ion density upstream of the shock	0	cm^{-3}	153	cm^{-3}
θ_{bn}	Angle between the shock normal and upstream magnetic field	23	deg	90	deg
R_{cB}	Magnetic compression ratio $\|B_{ds}\|/\|B_{us}\|$	1		11	
R_{cn}	Density compression ratio n_{ds}/n_{us}	1		1	
R_{os}	Magnetic field overshoot $(B_m - B_{ds})/B_{ds}$	0		2.4	
M_A	Shock Alfvén Mach number	0		27	
M_{ms}	Shock magnetosonic Mach number	0			
V_{sh}	Shock front speed	0	km/s	191	km/s
L_f	Spatial length of the shock foot	0	km		km
L_r	Spatial scale of the shock ramp	0	km		km
L_{os}	Spatial scale of the overshoot	0	km		km

☐ Include quicklook plots with your database

[Submit]

Or, to start again from scratch:
[Clear all selections]

- The database will have an online interface
- You will be able to download the entire database or **select subsets matching your criteria**
- Left shows a very preliminary example of the interface
- IP shocks from THEMIS will also be part of the database
- Output will be the database and quick-looks