Solar and space weather research at the Institute of Astronomy (BAS)

Научни изследвания в областта на слънчевата физика и космическо време в Института по астрономия - БАН

Rositsa Miteva
IANAO-BAS
rmiteva@nao-rozhen.org

https://bulgarianspace.online/nafski2023/

Institute of Astronomy with NAO - BAS

- BAS-Sofia https://astro.bas.bg/
- AO-Belogradchik https://www.astro.bas.bg/AOBel/index.php
- NAO-Rozhen (1981) https://nao-rozhen.org/

Topics of research
- Sun & Solar system
- Star & Stellar systems
- Galaxies & Cosmology

40 ГОДИНИ НАО Рожен

History: Solar research in BG

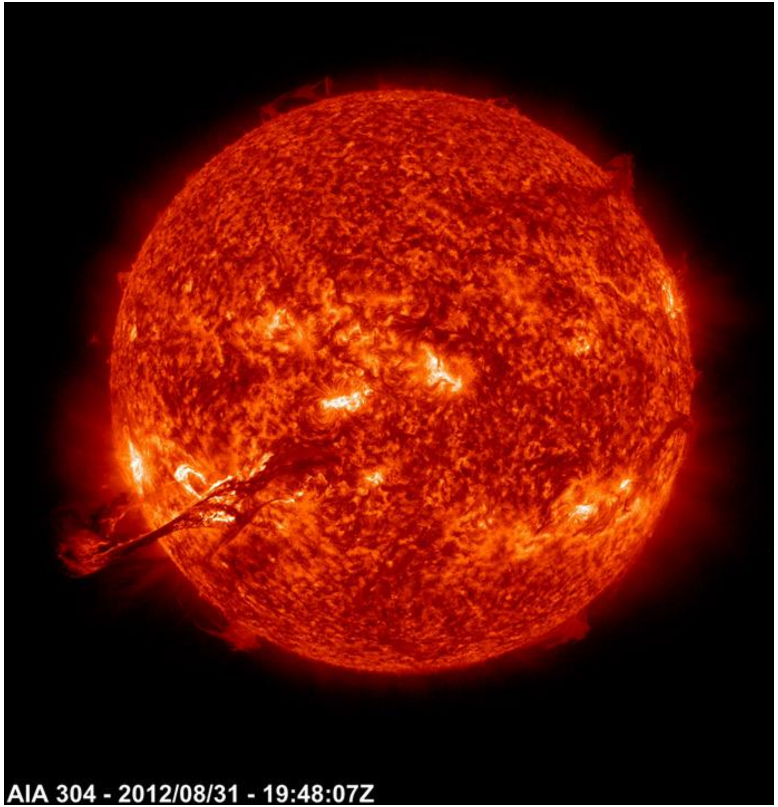
Topics of research (1990s, 2000s)

- Solar activity:

filament/prominence eruptions

- Total solar eclipses

- Theoretical research (2D MHD models)



https://sdo.gsfc.nasa.gov/gallery/main/item/157

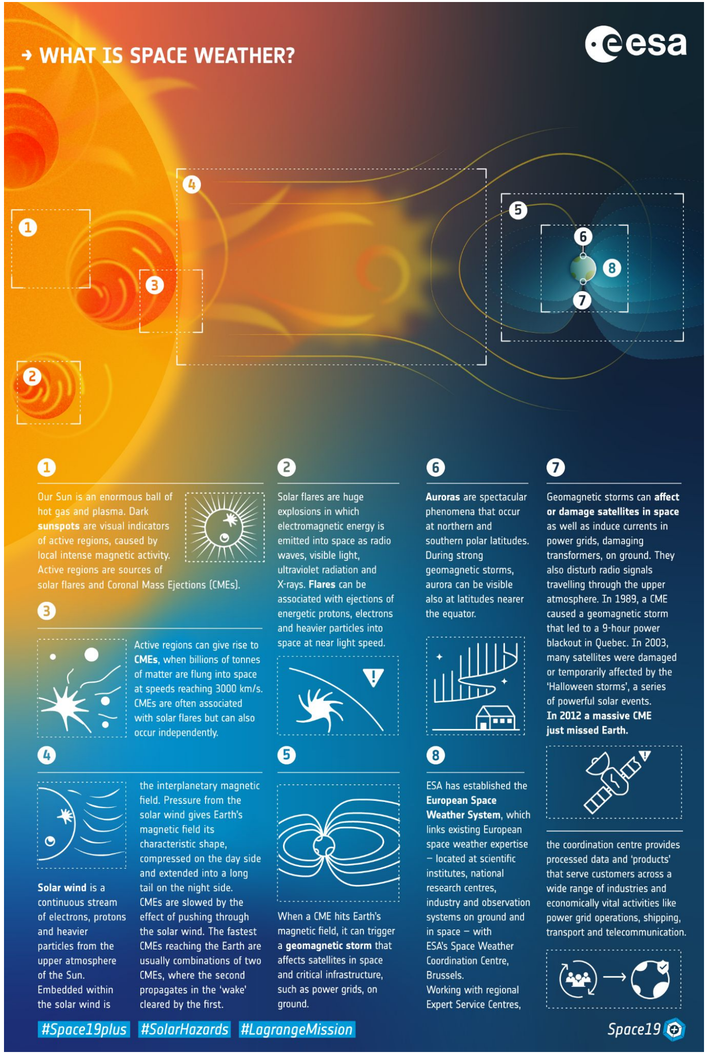
Present: Sun & space weather group

Topics of research (2010 - now)

- Solar activity: solar flares, filaments, radio bursts
  - multiwavelength analysis (focus on optical, EUV & radio data)

- Space weather
  - particles (data analyses, modeling & forecasting)
  - geomagnetic storms (statistics)

- Machine learning in solar/space weather



Completed projects

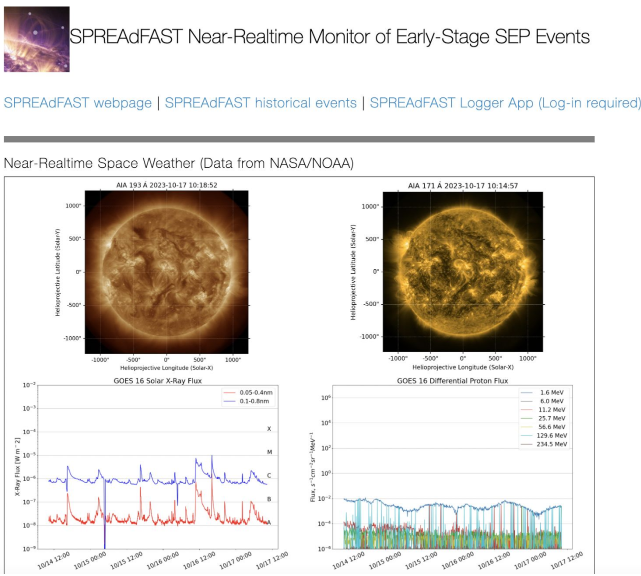
- **SPREADFAST**

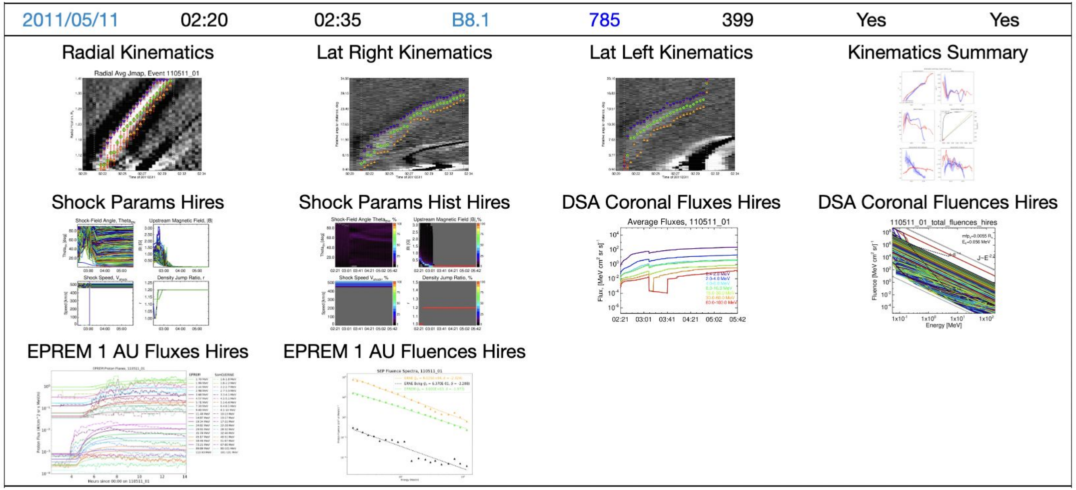
https://spreadfast.astro.bas.bg/synoptic/

Prototype of of a **forecasting** system, based on physics-based model for acceleration of solar energetic particles and their transport to Earth (ESA project); featured in SEP review

- **STELLAR**

https://stellar-h2020.eu/



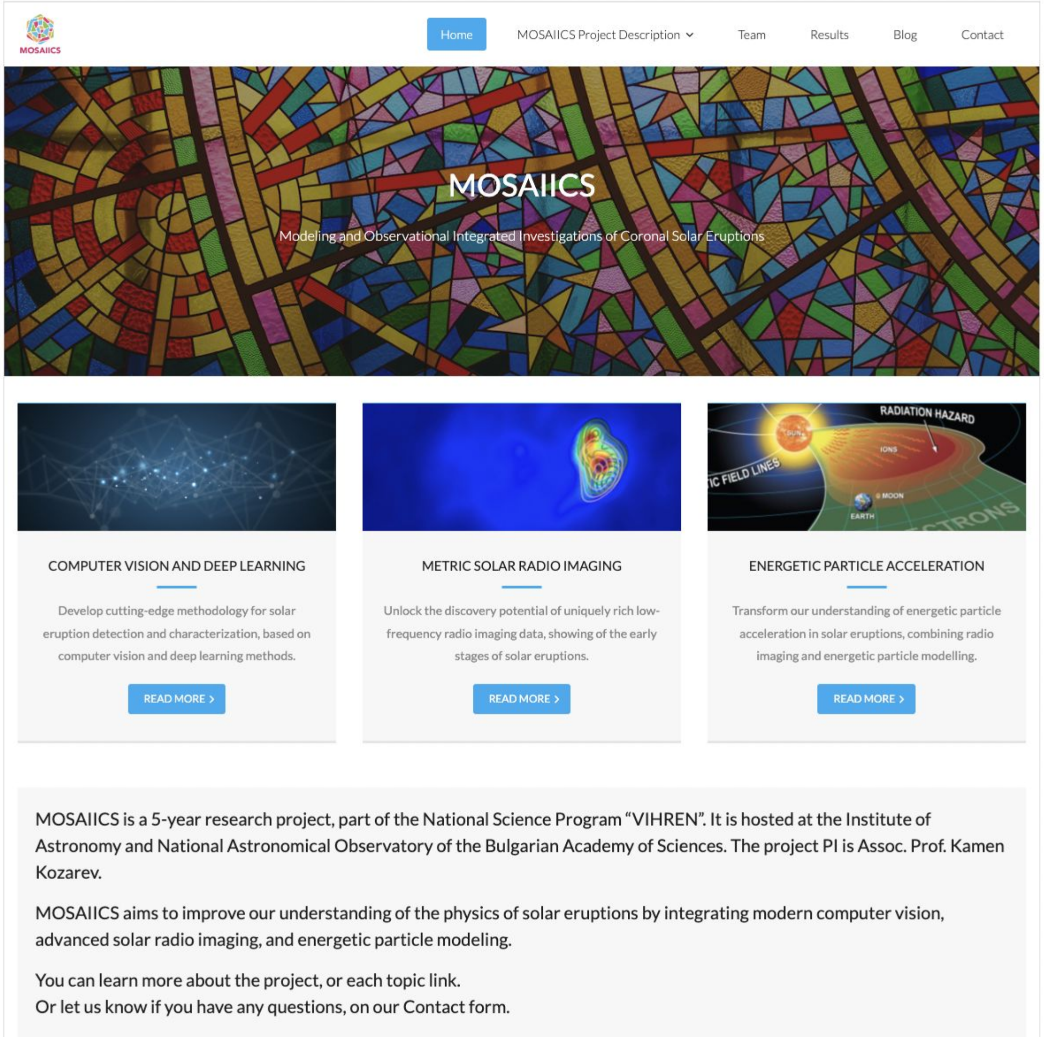


Projects in progress

- **MOSAIICS:**

Modeling and Observational Integrated Investigations of Coronal Solar Eruptions

https://mosaiics.astro.bas.bg/

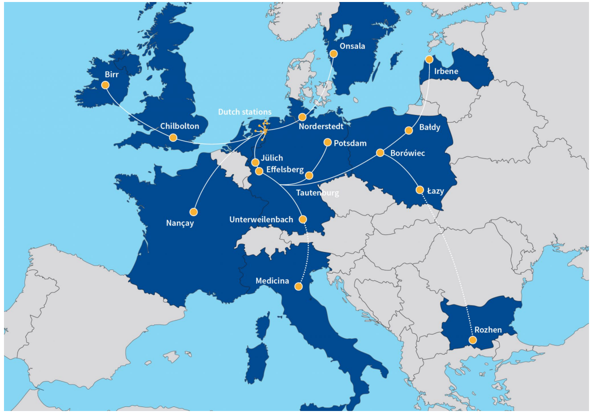


Projects in progress

- New chromospheric telescope at NAO-Rozhen https://helio.astro.bas.bg/observations

- New radio station:

LOFAR-BG https://lofar.bg/bg/



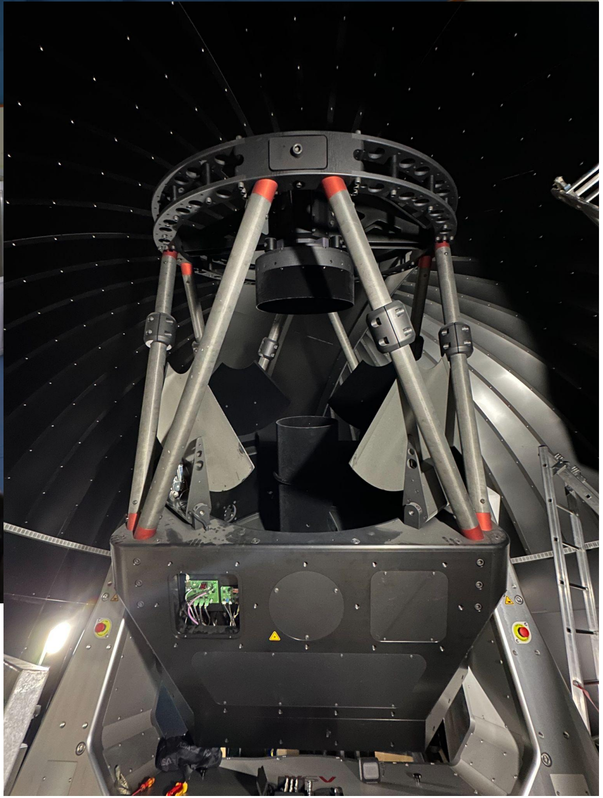
- New neutron monitor https://helio.astro.bas.bg/observations

Credit: Petrov (2021)

Infrastructure

NAO-Rozhen: Bulgarian center of astronomy, solar and space weather research

- 2-m & 1.5 m telescopes
- 30-cm solar telescope
- Radio station
- Neutron monitor
- Weather station, etc.



Present: Bilateral collaborations

Serbia (past & ongoing)

- ***Active events*** on the Sun, ***catalogs of proton events*** and electron Signatures…

India (past)

- ***Eruptions, flows and waves*** in the solar atmosphere and their ***influences on the space weather***

Egypt (ongoing)

- relationship between major ***space weather phenomena*** in solar cycles 23 and 24
- ***space weather effects*** at near Earth environment - from remote observations and in situ particle forecasting to impacts on satellites

Austria (past & ongoing)

- The ***origin of solar energetic particles***: solar flares vs. coronal mass ejections
- solar chromospheric and ***coronal activity***

http://edu-pro.astro.bas.bg/sun/?page_id=368

Research: Catalogs of space weather events

Database of analysed events:
https://catalogs.astro.bas.bg/

- **Protons**
- Solar flares
- Radio bursts
- Geomagnetic storms

CATALOGS OF SOLAR ENERGETIC PROTONS AND SPACE WEATHER EVENTS

AIM | PROTON EVENTS | SXR FLARES | RADIO BURSTS | GEOMAGNETIC STORMS | TYPE II BURSTS

Solar Cycle 23 – Protons

Show 10 entries

Search:

Year	m	d	Class	flare start	flare max	latitude	longitude	CME onset	CME speed	CME AW	Channel 1	onset UT	peak UT	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Channel 7	Channel 8	Channel 9	Channel 10
1996	7	9	X2.6	09:05	09:11	-10	30	gap	gap	gap	0.004401	09:44	10:52	0.002427	0.001022	0.000979	no	no	no	no	no	no
1996	8	13	u	u	u	u	u	16:09	620	153	0.008504	18:15	22:03	0.005586	0.002268	0.001914	0.00121	0.000892	no	no	no	no
1996	11	26	B9.0	20:48	24:32	u	u	21:36	548	78	0.001545	24:31	26:39	0.000702	0.000657	no	no	no	no	no	no	no
1996	11	27	u	u	u	u	u	u	u	u	0.001879	14:33	15:11	0.000916	0.000431	no	no	no	no	no	no	no
1996	11	28	C1.3	15:35	17:32	u	u	16:50	984	101	0.009031	19:38	22:12	0.005472	0.001592	0.00116	0.000721	no	no	no	no	no
1996	11	29	u	u	u	u	u	u	u	u	0.006815	05:30	13:49	0.002708	0.001147	0.000987	no	no	no	no	no	no
1996	11	30	u	u	u	u	u	u	u	u	0.02436	06:22	07:13	0.013896	0.004013	0.003175	0.001388	0.000415	no	no	no	no
1996	11	30	M1.0	20:16	20:44	-6	47	n	n	n	0.002383	23:29	28:38	0.00101	0.000519	no	no	no	no	no	no	no
1996	12	24	C2.1	13:03	13:11	5	95	13:29	325	69	0.010562	15:05	18:06	0.006228	0.003103	0.002215	0.001172	0.000794	0.000459	no	no	no

Showing 1 to 9 of 9 entries

Previous Next

Note: Only a preview of the results during 1996 is shown. The channel selected for the proton event identification is Channel 2.

Abbreviations:

- AW – angular width
- CME – coronal mass ejection
- gap – data gap
- no – no proton event
- u – uncertain

Notations:

- all times are in UT
- Channels (in MeV): **1**: 14-17; **2**: 17-22; **3**: 21-28; **4**: 26-32; **5**: 32-40; **6**: 40-51; **7**: 51-67; **8**: 64-80; **9**: 80-101; **10**: 101-131
- class: flare peak in GOES soft X-ray flux (W/m^2)
- CME speed: linear speed (km/s) from https://cdaw.gsfc.nasa.gov/CME_list/index.html
- flare latitude: North (positive); South (negative)
- flare longitude: West (positive); East (negative)

Research: Catalogs of space weather events

Database of analysed events: https://catalogs.astro.bas.bg/

- Protons
- **Solar flares**
- Radio bursts
- Geomagnetic storms

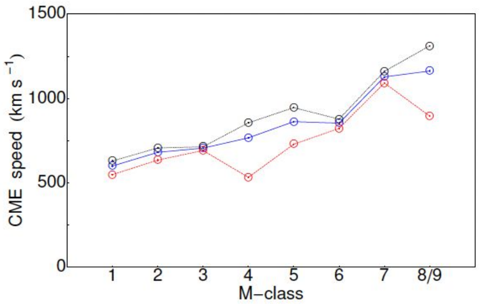
universe MDPI

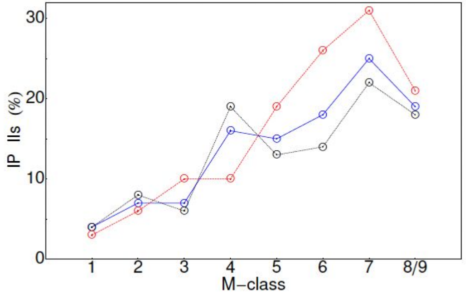
Article

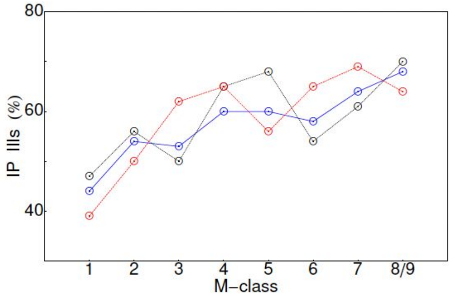
M-Class Solar Flares in Solar Cycles 23 and 24: Properties and Space Weather Relevance

Rositsa Miteva [1,*] and Susan W. Samwel [2]

Solar Event	SCs23 + 24
SFs	2177 (100%)
CMEs	889 (41%)
β	655 (30%)
β-γ	481 (22%)
β-γ-δ	663 (30%)
SEPs	133 (6%)
SEEs	247 (11%)
IP-III	1078 (50%)
IP-II	148 (7%)







Research: Catalogs of space weather events

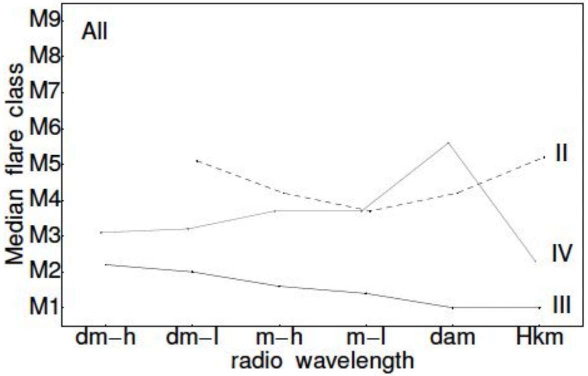
Database of analysed events:
https://catalogs.astro.bas.bg/

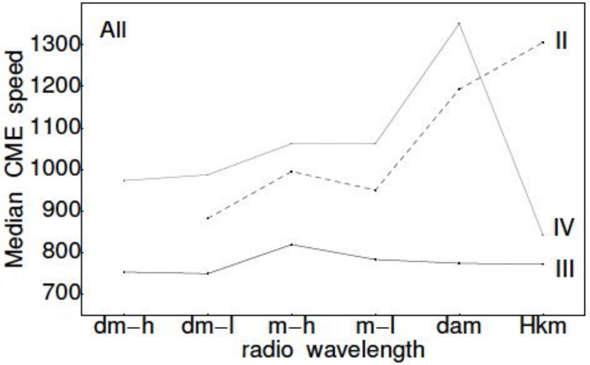
- Protons
- Solar flares
- **Radio bursts**
- Geomagnetic storms

universe MDPI

Article
Solar Radio Bursts Associated with In Situ Detected Energetic Electrons in Solar Cycles 23 and 24

Rositsa Miteva [1,*], Susan W. Samwel [2] and Svetoslav Zabunov [3]





Research: Catalogs of space weather events

Database of analysed events:
https://catalogs.astro.bas.bg/

- Protons
- Solar flares
- Radio bursts
- **Geomagnetic storms**

Advances in Space Research
Volume 72, Issue 8, 15 October 2023, Pages 3440-3453

Correlations between space weather parameters during intense geomagnetic storms: Analytical study

Susan Samwel [a], Rositsa Miteva [b]

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- strong correlation between |Dst| and both B_{total} and $|B_z|$;
- moderate correlation between |Dst| and solar wind parameters, except with solar wind density N_{SW} which shows almost no correlation;
- the |Dst| is highly correlated with $|V_{\mathrm{SW}}B_z|$ when compared with its correlation with V_{SW} and $|B_z|$ separately;
- with the exception to V_{ICME} which shows high correlation with |Dst|, the solar activity parameters (V_{CME}, AW, and I_{SXR}) show weak/no correlation with |Dst|;
- poor correlations are found between the parameters (flux and fluences) of the solar energetic particles, whether protons or electrons, with |Dst|.

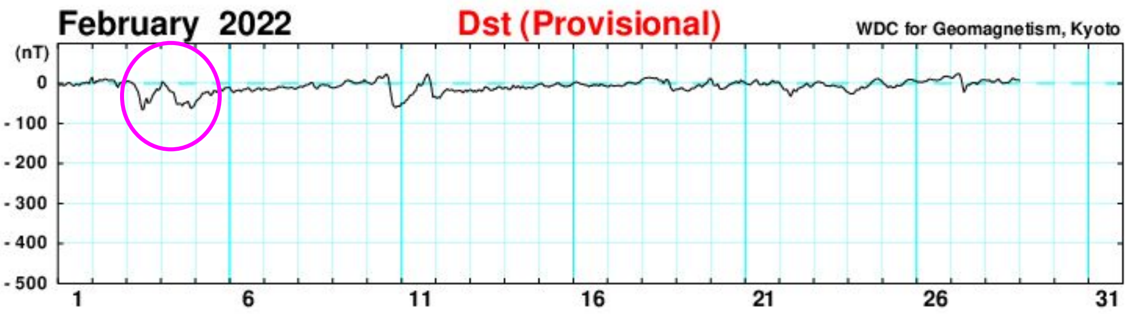
Completed	In progress
Dst ≤ −100 nT	=> **≤ −50 nT**
~100 GSs	=> **+~400 GSs**

Research: Space weather effects on satellites

Orbit:
210 km orbit (VLEO)

Facts:
2022-02-03
38/49 loss
minor geo-storms:
-66, -62 nT

Possible causes on the failure:
(1) Increased atmospheric drag - increased mass density
(2) GSs in close succession



Although the majority of the previous research [57–62] concluded that the notable Starlink failure was due to the increased atmospheric drag, ranging from 20–30% up to 150% at the staging orbit of 210 km, some doubts are raised if that it is the sole cause [63]. Despite the fact that the latter also estimated an increased thermospheric mass density by 35%, these authors proposed that GSs occurring in close succession (within about one day) are accountable for more negative SW effects on spacecraft operation and stability. The effects of the atmospheric drag on LEO satellites has been the topic of intense research, e.g., [48,49] and the references therein. Although it is well known that GSs lead to a global increase in the thermospheric neutral density, Joule heating due to EUV flare emission, and particle precipitation cause additional expansion in the 100–200 km region (or VLEO) [62].

Research: Space weather effects on satellites

Focus:
solar (**solar flares**) & (near-Earth) IP contributions (**protons**, **electrons**) at the time of selected Starlink launches

Aim:
in order to evaluate the additional impact of the EM and radiation environment on satellite stability

Input:
Timing of all (~100) Starlink launches 2019-2022 => 15 with Dst <=-25 nT

https://doi.org/10.3390/astronomy2030012

Table 2. Starlink launches and accompanied magnetospheric and IP phenomena: date (yyyy-mm-dd) and time (hh:mm) of the Starlink launches; day (dd), nearest hour (hh), and value (in nT) of the Dst index of the GS; day/time/speed (in km s^{-1}) of the ICME; day/time/speed (in km s^{-1}) of the IP shock, density jump at the shock surface (in cm^{-3}); day/time/value (in nT) for B_z component. All times are in UT. No reported events are denoted with 'no'.

Starlink Launch Date	Starlink Launch hh:mm	GS Dst dd/hh/nT	ICME dd/hh/km s^{-1}	IP Shock dd/hh/km s^{-1}	IP Shock cm^{-3}	B_z dd/hh:mm/nT
2020-04-22	19:31	20/13/−59	20/09/330	20/01:33/336	6.7	20/11:52/−15
2020-10-06	11:30	05/22/−40	05/17/350	no	no	05/19:34/−9
2020-10-24	15:32	24/07/−38	no	no	no	23/20:16/−12
2021-02-16	04:00	17/06/−54	no	no	no	13/03:07/−12
2021-03-04	08:25	03/05/−39	no	no	no	01/04:05/−14
2021-03-14	10:01	14/10/−43	no	no	no	13/05:06/−13
2021-05-26	18:59	27/09/−28	26/05/410	26/11:45/369	10.9	27/06:15/−11
2021-12-02	23:12	02/23/−25	no	no	no	02/15:02/−5
2022-01-19	02:03	19/04/−44	19/05/610	18/22:58/820	1.2	19/05:05/−6
2022-02-03	18:13	03/11/−66	02/16/460	01/22:27/543	4.2	03/09:37/−19
2022-04-29	21:27	30/08/−37	no	no	no	27/13:01/−11
2022-05-13	22:08	13/22/−39	no	no	no	11/19:55/−10
2022-07-07	13:11	07/23/−81	07/12/380	no	no	07/12:48/−16
2022-09-05	02:10	04/17/−72	no	no	no	04/05:24/−10
2022-12-28	09:34	27/16/−68	no	no	no	26/12:24/−10

Research: Space weather effects on satellites

Results:

➔ Minor to moderate effects due to solar flares, particle radiation & IP plasma density, B-field, velocity

Open ?s:

➔ Double GSs as a possible cause for satellite failure

Table 3. Starlink launches and accompanied solar/SW phenomena: date (yyyy-mm-dd) and time (hh:mm) of the Starlink launches; SF day/start/peak/end time/class; SEP day/peak time; SEE day/peak time. All times are in UT. Abbreviations: on: ongoing; pr: preceding; s: start time; su: succeeding.

Starlink Launch		SFs	SEPs	SEEs
Date	hh:mm	dd/hh:mm/class	dd/hh:mm	dd/hh:mm
2020-04-22	19:31	no	no	no
2020-10-06	11:30	no	no	no
2020-10-24	15:32	no	no	no
2021-02-16	04:00	no	no	no
2021-03-04	08:25	no	no	no
2021-03-14	10:01	no	no	no
2021-05-26	18:59	26^{on}/18:51/18:58/19:47/B7.0	no	no
2021-12-02	23:12	no	no	no
2022-01-19	02:03	no	no	18^{on}/19:26^{s}
2022-02-03	18:13	02^{pr}/17:42/17:47/17:59/C1.1	no	03^{su}/22:35
2022-04-29	21:27	29^{su}/22:42/22:56/23:14/C3.0	29^{on}/17:03	29^{on}/09:12
2022-05-13	22:08	13^{on}/22:07/22:26/22:34/C2.6	no	no
2022-07-07	13:11	no	no	no
2022-09-05	02:10	05^{on}/01:53/02:05/02:19/C5.0	no	no
2022-12-28	09:34	22^{on}/09:34/09:42/09:49/C2.4	no	no

Education

University courses

- Solar physics & solar activity; Radio astronomy (Master program, “Astronomy and Astrophysics” https://www.phys.uni-sofia.bg/?page_id=3443)
- Introduction to Space weather (Master program "Aerospace Engineering and Communications" https://www.phys.uni-sofia.bg/?page_id=6373) https://astro.phys.uni-sofia.bg/p9/

(New) Summer practice (start 2024: under development): students, PhDs, young scientists

Knowledge transfer

Summer schools & practices

- Project-related https://stellar-h2020.eu/
- LOFAR-BG https://lofar.bg/
- Branch Cosmos https://bulgarianspace.online/archive-schools/

Workshops

- Radio Astronomy

(external school 15-19 Apr 2024: https://indico.astron.nl/event/315/
Deadline: 30 Nov 2023!)

- Astropy

(20-24 Nov 2023: https://astro.bas.bg/astropy2023/ Registration closes today!)

Dissemination & outreach

- News (https://astro.bas.bg/)

http://195.96.236.171/news

Преследване на слънчевата корона до Западна Австралия
Лекция на гл. ас. д-р Цветан Цветков в МГУ „Св. Иван Рилски“

Dissemination & outreach

- News

http://195.96.236.171/news

- exhibitions

Ongoing: New 1.5-m telescope (BAS)

Начало Администрация Академията Документи

понеделник, 9 октомври 2023 | Категории: Астрономия, космически изследвания и технологии | Етикети: ИА с НАО

Изложба на изображения на космически обекти, заснети с новия 1,5-м телескоп в Националната астрономическа обсерватория (НАО) Рожен, беше открита в Българската академия на науките. Телескопът работи в полуавтоматичен режим и може да бъде управляван дистанционно, каза директорът на Института по астрономия с НАО проф. Евгени Семков. Той представи автора на фотографиите – астрономът гл. ас. д-р Милен Минев.

В експозицията са включени снимки на планетата Юпитер и на звезди, мъглявини, галактики, звездни купове и образувания от междузвезден газ и прах като известните „Стълбове на сътворението" в мъглявината Орел на съзвездието Змия.

Телескопът е първата мащабна научна инфраструктура, която е изградена изцяло с българско финансиране, каза председателят на БАН акад. Юлиан Ревалски и допълни, че средствата, вложени в проекта, са 3,5 милиона лева.

В зала „Проф. Марин Дринов" на БАН беше излъчен премиерно документален филм „Новият телескоп", с автори журналистът Димитър Сотиров и операторът Валентин Паскалев.

Dissemination & outreach

- News

http://195.96.236.171/news

- exhibitions

Ongoing: New 1.5-m telescope (BAS)

Dissemination & outreach

- News

http://195.96.236.171/news

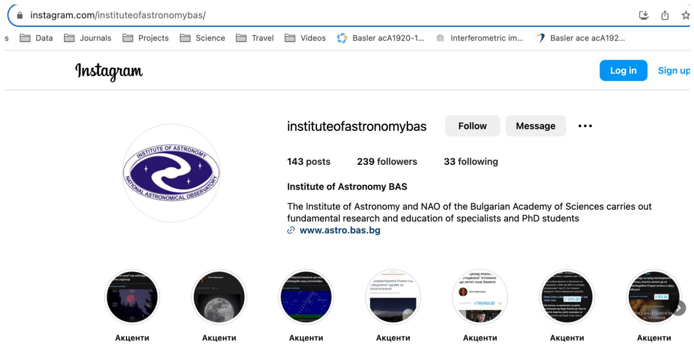
- exhibitions

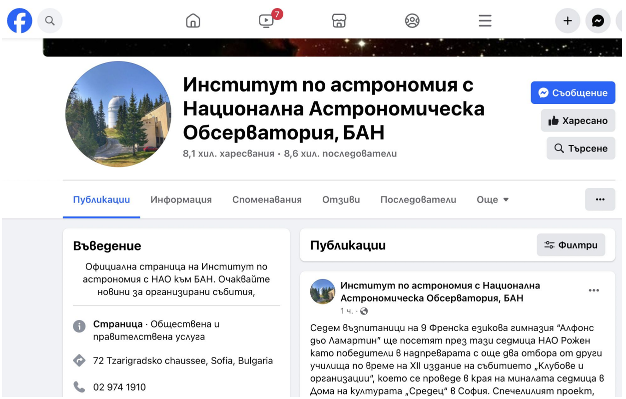
Ongoing: New 1.5-m telescope (BAS)

- science & public events

https://www.astro.bas.bg/reports/

- social media: facebook, instagram, youtube





https://www.youtube.com/@instituteofastronomyandnao6152

https://www.instagram.com/instituteofastronomybas/

https://www.facebook.com/ianaoban

Acknowledgements

SCOSTEP/PRESTO 2020 grant https://scostep.org/presto/
'On the relationship between major space weather phenomena in solar cycles 23 and 24'

Interacademy bilateral project (BAS): Bulgaria-Egypt
'On space weather effects at near Earth environment - from remote observations and in situ particle forecasting to impacts on satellites' IC-EG/08/2022-2024'

Bulgarian National Science Fund: Bulgaria-Austria
'Joint observations and investigations of solar chromospheric and coronal activity' KP-06-Austria/5 (14-08-2023)

European Space Agency (ESA): https://spreadfast.astro.bas.bg/

EU-Horizon 2020 (twinning project): STELLAR (Scientific and Technological Excellence by Leveraging LOFAR Advancements in Radio Astronomy) https://stellar-h2020.eu/

Ministry of Education, Bulgaria: LOFAR-BG https://lofar.bg/