DELIVERABLE D20.6

Report on the Facilities for Coordination

WP20 Integrated Operation and Exploitation of Solar Physics Facilities and Coordination with other Research Infrastructures

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SOLARNET

HIGH RESOLUTION SOLAR PHYSICS NETWORK

COORDINATED OBSERVARTIONS WITH SOLAR FACILITIES

Part 1

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Scope

This report implements the first part of WP 20.4 "Coordination with Other Infrastructures" and represents the deliverable D20.6, "Report on the facilities for coordination".

Solar phenomena occur with a very diverse range of spatial and temporal scales, which often makes it difficult to describe and comprehend fully the underlying physical processes. Solar physicists all over the world use ground based telescopes with apertures ranging from decimeters to more than a meter to image the whole solar disk and to resolve scales smaller than 100 km on the solar surface, throughout the visible and infrared spectral regimes. Space observatories cover the visible, ultra-violet and X-ray spectral regimes, usually with smaller apertures and a limited spectral coverage.

The time scales of physical phenomena on and in the Sun range from mere seconds (energetic events in the upper solar atmosphere) over minutes (oscillation and convection), hours (small scale magnetic structures in active regions), days (evolution of sunspots), weeks and months (evolution of active regions) to decades (solar activity cycle and its fluctuations). A comprehensive picture of the evolution of solar active regions, which play a key role in the energetics of flares and coronal mass ejections, can be obtained only with continuous observations of the solar surface, with high and low resolution, throughout the entire spectral range.

Recent experience has shown that the best results are obtained when the specific strengths of ground and space observatories are combined by simultaneous observations. Solar space observatories usually observe the Sun "around the clock" while producing very consistent sets of high quality data, but the diagnostics they are able to deliver are limited to the absolute necessary and data rates are limited by the capabilities of radio links. Last but not least, telescopes on the ground ultimately have higher spatial resolution because their apertures can be made large at lower cost.

On the other hand, observations from the ground are limited by the length of the day. This limitation can be overcome by coordinating observatories around the world. This approach has been pursued successfully by several world-wide, dedicated networks of small telescopes to observe solar oscillations (e. g., GONG, USA; IRIS and Bison, Europe). Several decades of data have been obtained with these networks which continue to contribute new insights in the workings of the solar interior. Coordinated observations with larger telescopes around the world have so far been rarely attempted. The main issues are governance and access issues, the compatibility of data products and the lack of coordination in the respective time allocation processes. The purpose of this work package is to establish a basis from which European solar astronomers can coordinate their observations with observing facilities around the world in the form of international collaborations outside Europe. This includes ground based observations which are coordinated with campaigns on space observatories.

The near-term goal of this work package is to coordinate a joint, global observing campaign with high resolution telescopes around the world, supported by other observatories, of a region on the solar surface as it crosses the visible solar disk for half a solar rotation. This campaign would take two weeks of joint observations during the last year of the current SOLARNET contract in 2016. All data obtained shall be shared by all participants. The goal is to include a core of ground based high resolution telescopes into the full observing program, while synoptic ground based and space observatories provide supplementary observations. A long term goal of this activity, reaching beyond the time frame of the present activity, is to establish the roots of globally coordinated solar observations with high resolution solar telescopes in the area of the DKIST and the EST.

Coordinated Facilities

Core High Resolution Telescopes

The following telescopes or facilities are considered essential for the success of this work package. All operators will be approached and asked to commit observing time for the full extent of the campaign. Time zones are an indication for the difference in geographic longitude, reflecting the coverage of the day.

This collection contains information on the instrumentation available at a particular telescope which will be used during the observing campaign. The following types of instruments are considered:

Designation	Description	Remarks
IM	High resolution Imager	Low spectral resolution, high spatial resolution solar surface imager
LSV	Longslit spectropolarimeter, visible	High spectral resolution spectrograph (grating) with polarimetry, simultaneous Xλ, visible range within 380 … 900 nm
LSIR	Longslit spectropolarimeter, infrared	High spectral resolution spectrograph (grating) with polarimetry, simultaneous Xλ, infrared range within 1 µm … 2.5 µm
PSV	Panoramic spectropolarimeter, visible	Medium spectral resolution spectrograph (filtergraph) with polarimetry, simultaneous XY, visible range within 380 … 900 nm
PSIR	Panoramic spectropolarimeter, infrared	Medium spectral resolution spectrograph (filtergraph) with polarimetry, simultaneous XY, infrared range within 1 µm … 2.5 µm

GREGOR

Location: Teide Observatory, Tenerife, Canary Islands, Europe
Local Time: UT + 0 h
Aperture: 1.5 m
Instrumentation: IM (BBI), LSIR (GRIS), PSV (GFPI)
Operated by: KIS, Germany
Time allocation: SOLARNET Access TAC
Remarks: simultaneous observations with GRIS and GFPI is preferred mode of observation

Swedish Solar Telescope (SST)

Location: Roque de los Muchachos Observatory, Canary Islands, Europe
Local Time: UT + 0 h
Aperture: 1.0 m
Instrumentation: LSV (TRIPPEL), PSV (CRISP)
Operated by: Sweden
Time allocation: SOLARNET Access TAC
Remarks: simultaneous observations with CRISP and TRIPPEL is preferred mode of observation, chromospheric capability with CRISP

THEMIS

Location:	Teide Observatory, Tenerife, Canary Islands, Europe
Local Time:	UT + 0 h
Aperture:	0.9 m
Instrumentation:	LSV (MTR), PSV (IPM)
Operated by:	THEMIS, France
Time allocation:	SOLARNET Access TAC
Remarks:	multi line capability

Dunn Solar Tower

Location:	Sunspot, New Mexico, United States of America
Local Time:	UT - 7 h
Aperture:	0.75 m
Instrumentation:	LSV (DLSP), LSIR (FIRS), PSV (IBIS), IM (ROSA)
Operated by:	NSO, USA
Time allocation:	NSO TAC
Remarks:	

New Solar Telescope

Location:	Big Bear Lake, California, United States of America
Local Time:	UT - 8 h
Aperture:	1.6 m
Instrumentation:	LSV (FISS), LSIR (CYRA*), PSV (VIM*), PSIR (IRIM), IM
Operated by:	NJIT, USA
Time allocation:	NJIT TAC
Remarks:	instruments marked with (*) currently under development

New Vacuum Solar Telescope

Location:	Fuxian Lake, Yunnan, Republic of China
Local Time:	UT + 8 h
Aperture:	1.0 m
Instrumentation:	IM, ??
Operated by:	Yunnan Astronomical Observatory, RC
Time allocation:	Yunnan TAC
Remarks:	

Auxiliary High Resolution Telescopes

The following telescopes or facilities are considered important for the success of this work package. All operators will be approached and asked to commit observing time for part of or the full extent of the campaign.

Europe

Name	Location	Aperture	Operated by	Time Zone (UT)
VTT	Canaries, OT	0.7 m	D / KIS	±0
DOT	Canaries, RdlM	0.45 m	NL	±0
IRSOL	Locarno	0.45 m	CH	+1
Einsteinturm	Potsdam	0.6 m	D / AIP	+1
Solar Tower	Meudon	0.6 m	F	+1

North America

Name	Location	Aperture	Operated by	Time Zone (UT)
McMath	Kitt Peak	1.6 m	USA	-7
VTT-SF	San Fernando	0.6 m	USA / Northridge	-8

Asia and Russia

Name	Location	Aperture	Operated by	Time Zone (UT)
DST	Hida	0.6 m	JP / Kyoto Univ.	+9
LSVT	Baikal Obs.	0.76 m	RUS / Irkutsk	+8
MAST	Udaipur	0.5 m	IN / Udaipur	+5:30

Optical Synoptic Facilities and Coronagraphs

Synoptic facilities observe the Sun continuously from the ground, weather permitting. Data collected with these facilities are usually made available to solar researchers. All operating institutions will be asked to join the collaboration and to provide their data for the period covered by the campaign, as well as for periods before and after.

Location	Aperture	Operated by	Time Zone (UT)	Remarks
Huairou	10 – 60 cm	CN / NAO Beijing	+8	VMag, Hα
ONSET	20 – 30 cm	CN	+8	Hα, 10830, WL
Kanzelhöhe	10 cm	AUS / Univ. Graz	+1	Hα
Maui (Mees)	20 – 30 cm	USA / Univ. Hawaii	-10	VMag, Hα
Ondrejov	50 cm	CZ	+1	VMag
Sunspot	40 cm	USA / NSO	-7	Cor (Evans)
Tatranska L.	20 cm	SK	+1	Cor
Tucson	50 cm	USA / NSO	-7	VMag (SOLIS)
Canaries, OT	10 cm	D / KIS	±0	Hα, 10830, Ca II K (ChroTel)

Networks

Ground based networks observe the Sun 24 hours a day for helioseismology and space weather monitoring. The following networks deliver data on a regular basis which will be used for data analysis as needed. The "far side imaging" capabilities of GONG will be essential for the planning of the campaign.

Name	Operated by	Remarks
GONG	USA / NSO	6 stations, dopplergrams, magnetograms, Hα
BISON	UK / Birmingham	6 stations, low l helioseismology

Radio Telescopes, Radioheliometers and Arrays

Radio telescopes observe the emission of accelerated electrons in the solar corona and therefore access a region which is difficult to observe in the optical regime from the ground. With the exception of ALMA and LOFAR, which are large general purpose radio telescopes, all radio facilities are dedicated for solar observations and produce synoptic data.

Both ALMA and LOFAR support solar observations. Applications will be made through their time allocation process for the period of joint campaign.

Name	Location	Operated by	Time Zone (UT)	Remarks
ALMA	Chajnantor	INT / JAO	-4	Sub - MM
LOFAR	Dwingeloo / EU	NL / ASTRON	+1	Long wave radio
Radioheliograph	Nancay	F / OPM	+1	
Radioheliograph	Nobeyama	JP / NRO	+9	
SSRT	Sanyan	RUS / ISTP	+8	
CSRH	Zhengxiang Baiqi	CN / NAO	+8	
Owens Valley Radio Station	Owens Valley	USA / NJIT	-8	

Coordination

Coordination with US Ground Based Solar Physics

The ground / space solar physics community in the US is likely the largest in the world, followed by the consolidated solar community in the European Union. It is the goal of this work package to establish long term links with all of these communities to establish world-wide coordinated observing as a joint scientific endeavor.

The short term goal is to establish the capability for coordinated observations with the European facilities in the Canaries, and the facilities of the National Solar Observatory (Dunn Solar Tower) as well as the New Solar Telescope of the New Jersey Institute of Technology's Big Bear Solar Observatory. The time difference between the Canaries and the US observatories ranges between six and seven hours, effectively extending the length of an observing campaign by that amount of time. A long term observing campaign, starting at one of the Canaries telescopes, can be continued with a partner telescope in the US with one to two hours overlap and may overall cover 12 to 14 hours, significantly longer than the optimistic 6 to 8 hours which could be covered by a single facility.

Coordination with Middle / Far East Ground Based Solar Physics

Russia pursues solar research for many decades and operates high resolution facilities in east Asia. India and China have significant and growing ground-based solar communities, and are currently building competing observing facilities.

The Chinese solar community is vividly evolving since several decades. The National Astronomical Observatories operate a variety of full-disk solar telescopes and magnetographs from several sites. Major facilities include the Huairou Solar Observing Station near Beijing with a 0.6m solar telescope, and the recently commissioned 1m Solar Vacuum telescope of Yunnan Observatory at Fuxian Lake in the south-west of China. The Chinese solar astronomy already has well established links with the European solar community.

India has a long standing history in solar research. The Udaipur Solar Observatory in Rajasthan, India, operates several smaller solar telescopes and is in the process of commissioning the 0.5m Multi-Application Solar Telescope (MAST) which will feature instruments with capabilities comparable to the larger solar telescopes in the US and Europe. The Institute for Astrophysics in Bangalore vigorously pursues a plan to develop a National Large Solar Telescope (NLST) with an aperture of 2m to be located in the Himalaya Mountains.

The time difference between the Canaries and the Udaipur Observatory are about 6 hours, the time difference to the Chinese observatories amounts to about 8 to 9 hours. The Sun sets in the Far East when it rises in the Canaries. Coordinated observations with Chinese and Indian observatories therefore also extend the coverage considerably. Coordinated observations with Far East and US telescopes would amount to uninterrupted solar observations throughout the day when weather conditions are favorable everywhere. It is therefore attractive to include solar observatories in the Far East into this framework, in order to create a truly global observing facility.

Coordination with Solar Physics in Space

The prominent space missions observing the Sun in the timeframe of this project are the Hinode mission, led by Japan, and the Solar Dynamics Observatory (SDO), led by the US.

Hinode combines a 0.5m telescope which observes the visible spectral regime with an X-ray telescope and a EUV imaging spectrometer. Under the leadership of the Japanese space agency JAXA, the Hinode mission is a collaboration including NASA, the British STFC and ESA. Many observing campaigns on ground based telescopes have been coordinated with observations with Hinode which consist of high resolution images and spectropolarimetry data with consistently excellent quality. The mission is expected to continue through the time frame of this proposal, i. e., 2013-2016. Integrating targeted Hinode observations into an international network of solar observatories is essential.

The Solar Dynamics Observatory produces images with high cadence in ten spectral bands covering the visible, UV and EUV spectral range, maps of the surface velocity and magnetic fields, as well as the integrated UV spectrum with high spectral and time resolution. SDO data are readily available and an invaluable resource for solar physicists today. Nominal mission duration is from 2010 to 2015 with the expectation that the mission will continue until the end of the decade.