Solar Physics Research Integrated Network Group (SPRING)

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1. INTRODUCTION:

SPRING stands for Solar Physics Research Integrated Network Group: a proposed new ground-based network of identical telescopes for synoptic observations of the Sun. Currently under design study, it is a program planned under auspices of SOLARNET program (SOALRNET is an European initiative for high-resolution solar physics).

SPRING will provide a wider range of solar observations and also with higher fidelity and coverage in spatial, spectral and/or temporal domain, than at present (such as by GONG, SOLIS and HMI).

Synoptic full-disk observations are crucial for addressing a variety of solar physics research problems (as briefly discussed below), and to serve as comprehensive context observations for next generation of high-resolution solar telescopes such as 4-m class DKIST (formerly known as ATST) and EST.

2. BASIC SCIENCE QUESTIONS

The large aperture telescopes observe limited area on the solar disk (typically few tens of arc-sec) in very fine detail. However, in order to interpret the observations correctly one requires contextual observations over larger field-of-view (preferably whole disk), over larger temporal domain (to understand the evolutionary history of the region) and also in different wavelength domains (to understand the coupling between different regions in the solar atmosphere).

The key areas of solar physics that will benefit from SPRING

• *Global Helioseismology*
- Solar Rotation Profile & variation with solar cycle
- Meridional and Zonal Flows & variation with solar cycle

• *Local Helioseismology*
- Subsurface flows in relation to emerging active regions
- Structure of subsurface flows in relation to sunspots, activity complexes

• *Atmospheric Seismology*
- Multi-height Seismology of Solar Atmosphere to determine plasma properties, stability/instability of structures such as filaments prior to eruptive events such as flares, CMEs
- Understanding energy transport in solar atmosphere (chromospheric heating)

• *Vector Magnetometry*
- Structure & Evolution of the magnetic field, electric currents in solar active regions and their relation to flares & coronal mass ejections.
- Multi-line magnetic field measurements to constrain 3-D magnetic topology via extrapolations
- Structure & Evolution of magnetic field over the solar cycle
- Long-term variations in the Sunspot field strengths

• *Multi-line imaging* of Fulldisk (blue,red, green continua, H-alpha core, wings, Ca-H, K lines, He-10830 etc.)

• *Solar Irradiance Measurements*
- Solar Irradiance variations in different wavelength bands
- Sun-as-a-star spectral indices of chromospheric lines.

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3. OBSERVING SPECIFICATIONS:

• Full-disk Doppler velocity, vector magnetic field, and intensity images
• Multiple-wavelengths
• Cadence of no longer than 60 seconds
• Spatial Resolution of 1″ (0.5″ pixels)
• 90% Duty Cycle
• 25 Year lifetime
• Velocity sensitivity: 5 m/s /pixel/image
• Magnetic Field Sensitivity: 10G /pixel/image

4. INSTRUMENT CONCEPTS

• Observations in Ni I 6768, Fe I 6301/2, Na D, H-α, Ca K, Ca H, He 10830, CA 8542, Fe I 6173, Fe I 1.5 μm
• Images of 4k x 4k pixels
• Entrance aperture of at least 0.5 m
• Adaptive optics or other image enhancement technology
• High-speed image post-processing
• Instruments located at least six sites
• High-speed real-time data return via the internet

Existing Synoptic Instruments:

SOLIS:

Full-disk Slit-Spectropolarimetry in Fe I 630 nm and Ca II 854 nm lines

Pros: High-spectral performance, minimal instrument polarization

Cons: Geometric Errors, variable seeing during scan, cadence too long (2 to 3 fulldisk magnetograms per day per wavelength).

GONG:

Dopplergrams with Michelson Interferometer in Ni I 676 nm line.

Pros: spectral stability, good cadence

Cons: Single spectral line, No vector magnetograms, smaller aperture

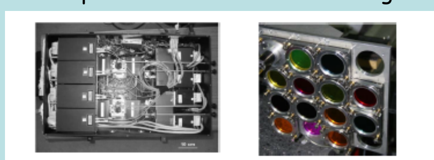
SOLIS

GONG

Multi-wavelength Doppler Imaging Concept

HELLRIDE instrument (*Staiger, J., 2011, A&A, 535, A83*) at VTT, Tenerife

• Matrix of fast-moving pre-filters along with tunable Fabry-Perot etalon
• Dopplergrams in 16 spectral lines with 21 wavelength samples in 1 min.



HELLRIDE Instrument Setup

Further Tests with HELLRIDE.

• Reduce the number of lines and add polarimetry capability.
• Extend F-o-V from 100 arc-sec square to Full-disk observations.

Major Challenges for SPRING:

1. CCD Cameras (4kx4k with fast readouts < 1sec for Dopplergrams and vector magnetograms; and possibly 8kx8k for high-resolution fulldisk imaging)
2. Stability of spectral measurements
3. Polychromatic Modulator Design for Polarimetry
4. High Data volumes, Data Archival and Realtime Pipeline processing
5. Six sites (optimal) or three sites (minimal), distributed globally.
6. Funding & logistics