

**OBSERVING TIME PROPOSAL FORM FOR
NEW SOLAR TELESCOPE (NST)**

1 General Information

1.1 Applicant Name and Affiliation

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*Note that Co-Is have the same data access rights as the PI. Please coordinate data access among team members.

1.2 Proposal Information

- Renewal or continuation
- Linked to an US NSF funding
- Linked to an NASA funding
- Linked to a PhD thesis in preparation and led by a PhD student
- A coordinated observation with a ground-based telescope
- A coordinated observation with a space-based observatory (e.g. IRIS or Hinode)

1.3 Observing Conditions

- Good Seeing
- Sky Clarity
- Low Water Vapor
- Specific Solar Activity
- Quiet Sun Observation
- Solar Limb Tracking

1.4 Preferred Observing Date and Time*

- Fixed Date: 13 - 19 June 2015
 - Flexible Date: 7 - 10 days in July and September
 - Fixed Observing Time: 18:20:45 UT - 19:00:05 UT
 - Suggested Observing Time: 16:30:00 UT - 22:30:00 UT
 - Observing Conditions Permitting
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*Note that Fridays may be occupied for telescope engineering time.

2 Scientific Rationale

2.1 Title

Studies of White-Light and Black-Light Flares using the 1.6 m NST

2.2 Abstract

In this proposal, we plan to observe solar flares in optical wavelengths including G-band at 4305 Å, red continuum at 6684 Å, and the He I 10830 Å. The required instruments are Broadband Filter Imagers (BFIs) and Near InfraRed Imaging Spectropolarimeter (NIRIS) with optional support from Visible Imaging Spectrometer (VIS) monitoring the H α emission. This multi-wavelength observation will provide rich information of flare dynamics and energetics. In particular, we plan to study two scientific topics related to solar flares:

- 1) The core-halo structure in white-light flares;
- 2) Black-light flares;

If success, this project will significantly advance our knowledge of energy deposition during solar flares.

2.3 Short Summary of the Request

We propose to observe solar flares in G-band, red continuum, and the spectral line at 10830 Å, by taking the advantage of NST's unprecedented resolution. The key instruments are BFIs and NIRIS with almost no change to the current setup. We plan to observe active regions with potential flare productivity. The expected targets are 'white-light' (WL) and 'black-light' (BL) flares, as their formation mechanisms are highly controversial. The red continuum around 6600 Å is among the best wavelengths in observing WL flares according to Hinode observations. G-band is a good proxy of WL and is sensitive to temperature change. In addition, G-band has relative higher spatial resolution than red continuum. Therefore, G-band and red continuum will be used to observe WL flares. The spectral line 10830 Å will be used for observing BL flares. Such an observation was carried out in 2013 and a BL flare was observed.

2.4 Scientific Rationale

The scientific targets are WL and BL flares. In the context of WL flare studies, Neidig et al. (1993) proposed that flare kernels consist of a bright inner core corresponding to the direct heating in the chromosphere and a weaker outer region (halo) corresponding to radiative backwarming. Xu et al. (2004), Xu et al. (2006) and Xu et al. (2010) explored this idea further using observations of NIR white-light emission with unprecedented spatial and temporal resolution. Xu et al. (2006) studied the temporal variations of core and halo and compared them with those of HXR in two white-light flares. We have demonstrated that the flare core and halo could be distinguished entirely with sub-arcsecond resolution in the NIR Xu et al. (2010). However, so far no clear evidence of core-halo structure has been observed by SDO/HMI. Note

that the WL observations of SDO/HMI are not obtained directly from filtergrams. Instead, they are extrapolated results from the spectral observations and therefore some details may be lost. We plan to take WL observations in the red continuum and G-band to study the existence and property of core-halo structure by taking NST's unprecedented resolution. In addition, there is a trend that large aperture telescopes are able to see weaker flares with WL emission. We are seeking M class flares with clear WL emission to be detected easily by NST.

Another key component of this proposal is to study the BL flares. Unlike the monotonic increase of intensity in most other wavelengths during a flare, observations at some spectral lines and continua show a dimming right before the impulsive phase of a flare (Zirin 1980; Feldman et al. 1983; Liu et al. 2001; Henoux et al. 1990; Liu et al. 2013). Essentially, BLFs appear in more impulsive flares with strong electron beam heating. Because the BLF source may be small, with a short lifetime, the small number of BLFs observed so far could well be due to the limited resolution and cadence of observations to date. On 2013 August 17, NST observed a BLF in the He 10830 Å, which is the very first observation of such kind. Our analysis found that the dark ribbon is extremely narrow, less than 500 km. However, there was no RHESSI data, which is important for performing modeling. IRIS also missed this event, so that we are not able to detect the temperature, which is the key factor distinguishing He 10830 from absorption to emission. The good news is that the BLF was an M1.4 flare. Flares of such a magnitude are often observed. Therefore, we plan to search more event using NIRIS at 10830 Å. This time we prefer to have spectral information.

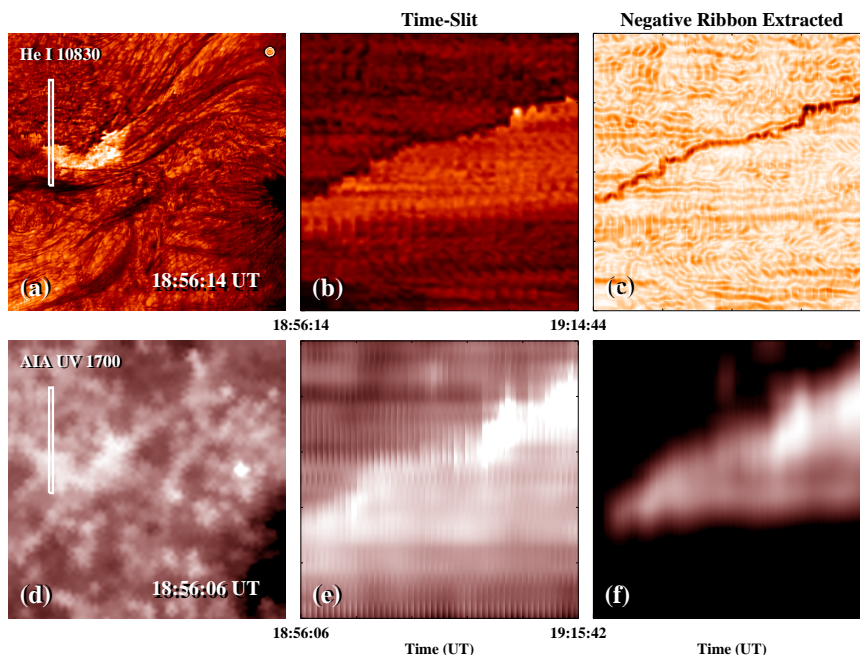


Figure 1: BLF in He 10830 observed by NST on 2013 August 17. The lower panel show the UV 1700 images without the dark flare ribbon.

2.5 Results from Previous NST Observations

The previous NST observation of a BLF is shown in the above section.

2.6 List of Relevant Publications

- Xu, Y., Jing, J., Wang, S., & Wang, H. 2014, ApJ, 787, 7
 Wang, H. et al. 2014, ApJ, 781, 23
 Wang, H. et al. 2013, ApJ, 774, 24
 Liu, C., Xu, Y. et al. 2013, ApJ, 774, 60
 Xu, Y., Cao, W., Jing, J. & Wang, H. 2012, ApJ, 750, L7
 Xu, Y., Cao, W., Jing, J. & Wang, H. 2010, Astron. Nachr., 331, 596
 Xu, Y., Cao, W., Liu, C. et al. 2006, ApJ, 641, 1210
 Xu, Y., Cao, W., Liu, C. et al. 2004, ApJ, 607, L131

2.7 Expected Results

3 Observing Programme

3.1 Instrumentation Requirements*

- Adaptive Optics (AO-308)
- Broad-band Filter Imager (BFI)
- Fast Imaging Solar Spectrograph (FISS)
- Visible Imaging Spectrometer (VIS)
- Infrared Imaging Spectro-polarimeter (NIRIS)
- Cryogenic Infrared Spectrograph (CYRA)
- Other

*Note that FISS and VIS can't be used simultaneously. CYRA can't operate with all other instruments simultaneously.

3.2 Observational Strategy

We plan to obtain 2D image sequences from BFIs in two spectral windows and 3D imaging spectroscopic data from NIRIS. Complementary images from VIS at H α core and wings (one blue, one red) are optional. The cadence is 15 to 30 s for both BFI images after speckle reconstruction and NIRIS/VIS 3D spectroscopic data. NIRIS should scan the 10830 line, centered at ~ 10830.3 Å and VIS scans the H α line with three steps at 0.0 and ± 1.0 Å.

Space data will be collected from RHESSI, SDO/HMI and IRIS. There is no specific arrangement needed for coordinated observations since RHESSI and SDO/HMI monitoring the entire solar disk and IRIS observation is optional.

3.3 Target and Conditions

The target would be any active region on the solar disk, which is possible to produce flares. If there are more than one active regions, we prefer to observe the region with more complicated magnetic configuration. If the magnetic configuration is undifferentiated, the active region that is more close to the disk center will be the target.

The scheduled observations require very good seeing condition under which AO-308 is able to lock granulation.