

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

1 General Information

1.1 Applicant Name and Affiliation

PI: **Xu, Yan** New Jersey Institute of Technology

Co-I*: **Wang, Haimin** New Jersey Institute of Technology

*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: 20 - 28 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
-

*Note that Fridays may be occupied for telescope engineering time.

2 Scientific Rationale

2.1 Title

**High resolution observations of white-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, H α at 6563 Å and the near infrared (NIR) at 15600 Å. The required instruments are Broadband Filter Imagers (BFIs) for G-band, Near InfraRed Imaging Spectropolarimeter (NIRIS) for 15600 Å and 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 three scientific topics related to solar flares:

- 1) The core-halo structure in white-light flares;
- 2) The un-shear motion of flare kernels;
- 3) The characteristics of flare emission from opacity minimum.

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, H α , and the NIR at 15600 Å, by taking the advantage of NST's unprecedented resolution. The key instruments are BFIs, VIS 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) flares, as their formation mechanisms are highly controversial. 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 will be used to observe WL flares instead of TiO band. The H α line has a long tradition in observing flares and provides rich information. With the capability of line scanning, we plan to study the property of central inversion pattern of the H α line emission during flares. The NIR radiation is believed to originate from the deepest layer of solar atmosphere. It is rarely used for flare observations in the literature. However, the proposal team has obtained flare observations using the BBSO's imaging system at NSO in 2003. We propose to take more observations at 15600 Å.

2.4 Scientific Rationale

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 HXRs 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 NIR 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.

From our previous observations, a notable un-shear motion was detected using the G-band images. However, due to the short duration and unstable seeing condition, that finding was not converted to a published result. In this proposal, we plan to search such un-shear motion in G-band during moderate flares (M-class or high C-class), since the G-band images may be saturated during strong flares.

Deng et al. (2013) present unprecedented 2-D H α imaging spectroscopy of a C4.1 flare observed on 2011 October 22. During the impulsive phase, core-halo structures are clearly identified. The emission spectra in the core areas show a central inversion pattern, which is the typical characteristics of the simulated H α line profiles caused by nonthermal electron beam precipitation (Ding & Fang 1997). Other spectral characteristics include broadening of the spectra, excess emission in the red wing (i.e., red asymmetry), and red shifted bisectors. In addition, we observed rather quick heating (~ 30 s) and cooling timescales in the flare core positions, suggesting impulsive heating of the core areas by nonthermal electrons. In contrast, the heating of the halo is more likely due to thermal conduction and/or SXR/EUV radiation. We are going to obtain more events for the central inversion pattern associated with the core emission.

2.5 Results from Previous NST Observations

N/A

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
Deng, N. et al. 2013, ApJ, 769, 112
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 using the G-band channel, 3D imaging spectroscopic data from VIS at $H\alpha$ and 2D image sequences at 15600 \AA using NIRIS without spectral scan and polarization. The cadence is 15 to 30 s for G-band and NIR after speckle reconstruction. The VIS should scan the $H\alpha$ line with all the 11 steps.

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.