

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

### Important Notes:

#### Two Proposal Submission Deadlines:

- 15 April 2015 for Session 1 (May 1 - June 30)
- 1 June 2015 for Session 2 (July 1 - 31 and September 15 - October 31)

1. Time window available for 2015: May 1 - July 31 and September 15 - October 31;
2. For the information of NST and BBSO, please visit <http://www.bbso.njit.edu>;
3. For the instrument information, feel free to contact Prof. Wenda Cao at [wcao@bbso.njit.edu](mailto:wcao@bbso.njit.edu);
4. Final decision on telescope allocation for session 1 and session 2 will be made no later than April 25 and June 15 2015, respectively by BBSO Telescope Allocation Committee (TAC). High priority may be given to the PIs who produced good scientific results from the previous observations, to the proposals with scientifically challenging and achievable objectives, and the observing proposal with coordinated observations.

**Make sure to submit your proposal in PDF format to Wenda Cao (TAC chair) via [wcao@bbso.njit.edu](mailto:wcao@bbso.njit.edu) before the deadlines**

Qualified internal and external applicants:

1. Internal applicants refer to the scientific staff residing at BBSO, scientists and students in NJIT's Center for Solar-Terrestrial Research, and BBSO partners.
2. External applicants refer to the scientists and students from the institutes or universities in USA recognized by NSF or NASA.
3. The PI must have a PhD degree or be a PhD student with the supervisor as the Co-I.

### Acknowledgement Requirement:

Please acknowledge BBSO and the instrument PIs in the paper relevant to this observation:  
*BBSO operation is supported by NJIT, US NSF AGS-1250818 and NASA NNX13AG14G*

# 1 General Information

## 1.1 Applicant Name and Affiliation

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|---------------|-------------------|------------------------------------|
| <b>PI:</b>    | <b>Penn, Matt</b> | National Solar Observatory         |
| <b>Co-I*:</b> | <b>Cao, Wenda</b> | New Jersey Institute of Technology |
| <b>Co-I*:</b> | <b>Xu, Yang</b>   | New Jersey Institute of Technology |

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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

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- ☒ **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

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

## 1.4 Preferred Observing Date and Time\*

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- ☒ **Fixed Date: 04 - 10 May 2015**
  - ☐ **Flexible Date:**
  - ☐ **Fixed Observing Time:**
  - ☒ **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

#### CYRA observations of Ti I at 2231nm

### 2.2 Abstract

Observations of sunspot velocity and magnetic field oscillations are proposed using the Ti I 2231nm spectral line. Testing of the CYRA vibrations and focusing will also be done using this line and the CO 4666nm spectral lines seen at the solar limb.

### 2.3 Short Summary of the Request

We will evaluate the CYRA cryo-cooler vibration with spectrum observations after applying weights to the cryocoolers, and do linearity, dark current, and light transfer tests for the CYRA detector. Assuming the CYRA instrument performs well, we plan to take scientific data and generate the first CYRA science paper about umbral oscillations as seen with the Ti 2231nm line.

### 2.4 Scientific Rationale

Observations of the 2231nm Ti I spectral line were made by Ruedi et al. (1998). These data showed the large magnetic splitting of the line and the temperature dependence in sunspots and the quiet Sun. Later observations by Penn et al. (2003) produced maps of the magnetic signature in a sunspot umbra and penumbra. For the magnetic fields in a sunspot, the line is completely split, and the effective magnetic sensitivity (given by the product of  $\lambda$  times  $g_{eff}$ ) is larger than the sensitivity of the famous 1565nm Fe I line.

Work from Bellot Rubio et al. (2000) measured the phase difference between the velocity and magnetic field oscillations observed in a sunspot using the 1565nm spectral line. Their work revealed a velocity oscillations at 100 m/s amplitude and magnetic field oscillations with 50 Gauss amplitudes, in a time sequence of only 22 minutes long with 5 seconds cadence. The phase difference measured between these oscillations was  $105 \pm 30$  degrees, which is consistent with the 90 degree V-B phase difference expected from changing the height of formation of the line in the presence of a constant magnetic field with a vertical gradient. They concluded that the magnetic field strength does not show intrinsic oscillations.

The CYRA instrument should be able to improve upon this work enormously, by using the more sensitive Ti I 2231nm line, by taking higher cadence observations, and by taking a longer time sequence (hopefully two hours or more). Data from CYRA should be able to determine if the phase shift is 90 degrees, or if there are other processes which do cause changes in the magnetic field strength inside a sunspot umbra.

## 2.5 Results from Previous NST Observations

No science observations with CYRA have been made yet.

## 2.6 List of Relevant Publications

Bellot Rubio et al 2000, ApJ 534 989

Penn et al 2003, ApJ 590 L119

Ruedi et al 1998, AA 338, 1089

## 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

Take engineering data at disk center, and at the limb using CO 4666nm. Then track a sunspot with the correlation tracker and take several hours of spectra at 2231nm.

## 3.3 Target and Conditions

Following a sunspot umbra for several hours during good seeing conditions