

Near InfraRed Tunable Filter (NIRTF) for a 2nd generation instrument of DKIST A. Asai¹, K. Ichimoto¹, T. Yokoyama¹, S. Nagata¹, S. Ueno¹, Y. Katsukawa², Y. Suematsu², Y. Hanaoka², M. Kubo², Y. Kawabata², and T. Anan³, ¹Kyoto University (17-1 Kitakasan-ohmine-cho, Yamashina-ku, Kyoto, 606-8502, Japan), ²National Astronomical Observatory of Japan (2-21-1 Osawa, Mitaka, Tokyo, 181-8588, Japan) and ³National Solar Observatory (22 Ohi'a Ku, Makawao, Hawaii, 96768, USA and tanan@nso.edu).

Introduction: In order to understand dynamic solar phenomena taking place on the scale of active regions, such as solar flares, we need a spectropolarimeter, which enables us to measure magnetic fields, the Doppler velocity, and motions on the plane of the sky in the photosphere, the chromosphere or the corona with a large field of view and high temporal cadence. A filter-based spectropolarimeter is the most suitable instrument to achieve them.

The National Science Foundation's Daniel K. Inouye Solar Telescope (DKIST) [1] achieves highly sensitive spectro-polarimetry not only for the photosphere and the chromosphere but also for the solar corona. However, DKIST does not have a filter-based spectropolarimeter for a near infrared spectral range, in which spectral lines sensitive to the magnetic and electric fields are contained. Kyoto University and the National Astronomical Observatory of Japan (NAOJ) have started to design scientific and technical concepts of an instrument, Near InfraRed Tunable Filter (NIRTF) in 2021 for a 2nd generation instrument of DKIST. In this presentation, we introduce the concept of NIRTF.

Science Objectives: The main science objective is measurements of the magnetic fields and velocities relating to plasma dynamics in the chromosphere and the corona.

For the solar corona above an active region, NIRTF is planned to measure the magnetic field using joint action of the Zeeman and Hanle effects. The ability to observe Alfvén waves with the large field of view and high temporal cadence allows us to obtain information on magnetic fields in the plane of the sky component through travel time analysis. On a large scale, temporal variation of the coronal magnetic field and conditions of magnetohydrodynamic instabilities causing large eruptions will be investigated to understand triggers of the solar flares and the coronal mass ejections. On a small scale such as the width of a coronal loop, the Alfvén speed will be estimated with density measurements for fundamental information about magnetic reconnection associated with solar flares and nanoflares.

For on-disk photospheric and chromospheric observations, NIRTF will provide suitable data for coronal magnetic field extrapolations and data-driven numerical simulations.

Requirements: The longer wavelength, the better sensitivity to the magnetic field and lower scatter light. The spectral range of NIRTF is from 1 μm to 1.6 μm . The range covers Fe I 1.56 μm , which is sensitive to photospheric magnetic fields, He I 1.08 μm , which is sensitive to chromospheric magnetic fields, the Paschen series of H I, which is sensitive to electric field, and Fe XIII 1.07 μm , which is sensitive to coronal magnetic fields. The requirements for NIRTF are to have good spectral resolution enough to resolve these spectral lines and wide free spectral range enough to cover them.

For on-disk observations of the photosphere and the chromosphere, the spatial resolution needs to be better than 0.1 arcsec and the field-of-view requires to be larger than 60 arcsec to cover a super granulation or a sunspot. The polarimetric sensitivity has to be better than 10^{-3} in 10 seconds. For off-limb observations of a prominence or the solar corona, we consider an option to switch the field-of-view to make it wider than 150 (TBD) arcsec for detecting the propagation of waves.

Prototype instruments: We have developed some prototype components for NIRTF, a tunable Lyot filter using Liquid crystal variable waveplate retarders [2], a Fabry-Perot filter using LiNbO₃ [3], and a large format infrared camera using H2RG [4], which is also used by 1st generation instruments of DKIST.

Current status: Scientific and technical concepts of NIRTF have been discussed and designed among the Japanese community since 2021. We submitted a letter of intent for NIRTF in response to the call for future plans by the subcommittee on Astronomy and Astrophysics in Science Council of Japan. NIRTF will be included in a future roadmap compiled by the Japan Solar Physics Community. The NIRTF is planned to be completed in late 2020s. It would be nice if we could discuss future collaboration and partnership between the U.S. and Japan in this workshop.

References: [1] Rimmele T. R. et al. (2020) Solar Physics, 295, 172 [2] Hagino, M. et al. (2014) SPIE, 9151, 91515V [3] Suematsu et al. (2021) Astronomical Society of Japan spring meeting, M04a [4] Hanaoka, Y. et al. (2020), Earth, Planets and Space 72, 181

Additional Information: N/A