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Title of Proposed Observation:

A Search Chromospheric Manifestation of Ubiquitous Photospheric Jets

Main Objective:

We propose to do a detailed search for and investigation of any chromospheric enhancement or dynamics associated with the small-scale, ubiquitous high-velocity events seen in the quiet photosphere.

Scientific Justification:

The discovery in Sunrise/IMaX data high-velocity events in the quiet Sun (Borrero et al. 2010) revealed the unexpected presence of supersonic motions in the quiet solar photosphere. However, the limited spectral sampling of the IMaX instrument precluded detailed study of these events. Follow-on studies (Martínez Pillet et al. 2011, Quintero Noda et al. 2014) used the extended wavelength coverage of the Hinode/SOT instruments to fully characterize the photospheric dynamics of this phenomenon. Martínez Pillet et al. (2011) suggested that the jets arise from reconnection of emerging fields with pre-existing fields in the photosphere. Using data from the spectro-polarimeter (SP) of Hinode/SOT, Quintero Noda et al. (2014) examined red-shifted magnetic signals located within the intergranular lanes, along with Doppler imaging in the upper photospheric Mg I b2 and imaging in the chromospheric Ca II H¬-line from Hinode/SOT, in an effort to identify a chromoshperic counterpart to these particular downward-flowing photospheric jets. They found that the majority of their red-shifted jets were associated with down flows seen in Mg I b2 line and bright points in the Ca II broadband images.

The question still remains as to whether these photospheric events can be connected with some dynamic or heating events in higher layers, and thus possibly a significant contributor to chromospheric heating and dynamics in the quiet Sun. For example, do the photospheric jets have a connection to the Rapid Blueshifted Excursions (RBEs, Langangen et al. 2008) now known to be associated with type II spicules? The previous studies of these photospheric jets were unable to determine a precise association with a chromospheric counterpart owing the broad spectral bandwidth of the Ca II imaging of Hinode/SOT, and also to the lack of spectroscopic data of the chromosphere. This limitation may now be addressed effectively with co-spatial, co-temporal spectroscopy using both Hinode/SOT SP and IRIS.

We propose to use co-spatial, co-temporal spectrographic observations using the Hinode/SOT spectro-polarimeter and IRIS spectrograph to search for chromospheric manifestations of the photospheric jets. Such observations should

be able to identify the connection, if it exists, and further to provide quantitative information on the dynamics and energetics of the associated phenomena. For this purpose we propose to carry out time series of short maps using both SP and IRIS. The Hinode/SOT SP will make repeated “very fast map” observations of quiet regions near the center of the disk, with a cadence of about one minute in order to temporally resolve the photospheric jets (lasting of order 3-4 minutes). From prior studies of these events, it is known that they occupy a few spatial resolution elements of the SP, so the compromise of spatial resolution rendered by the very fast map program should not be detrimental to the study. Further, with IRIS we propose to carry out spectrographic measurements of the Mg II h- or k-line, and if possible also lines forming at higher temperatures, co-aligned and co-temporal with the Hinode/SOT SP observations, and covering an area comparable in extent to the SP maps in order to compensate for pointing offsets between the two spacecraft.

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Dates: ToO

Time window: No specific time window, but avoid SAA and spacecraft night during eclipse periods. Each observational sequence should be uninterrupted. It is desirable to program observations outside of spacecraft eclipse season in order to increase the accuracy of co-alignment of the spectra from Hinode and IRIS.

Target(s) of interest: Quiet Sun, in the vicinity of disk center. Ultimately we would like this program to be run for about 20 one-hour sequences in normal quiet Sun near disk center, and also another 20 sequences in a coronal hole, also within 20 degrees or so of disk center.

SOT Requests:

Request initially one-hour time sequences using the SP “very fast mode” observational mode. Observations should be taken in dual-beam mode (acquisition of both sides of the SP CCD). An SP very fast map of 9” width (30 digitized steps of 0.297” each) requires 72 seconds. The effective pixel size is twice that possible with the SP, but analysis of prior observations of these photospheric events indicates that this resolution is sufficient to identify them and to carry out detailed analysis. Both sides of the CCD will be digitized in order to

enhance the signal-to-noise ratio, and to minimize effects of polarization crosstalk from residual image motion and solar evolution. The data acquisition will be limited to 768 pixels along the SP slit (384 digitized pixels, or 123”) to match the full length of the IRIS slit (120”).

Based upon prior observations of the photospheric jets, we expect to capture of the order of 20 events in 3-4 hours of observation. In order to build up significant statistics, we would like to plan for the initial observing program to acquire about 20 orbits of co-aligned data, which should yield about 200 separate events. This initial data will be subjected to analysis before proceeding with additional observations.

EIS Requests:

None.

XRT Requests:

None.

IRIS Requests:

The prime objective of this study is to ascertain the connections between the photosphere and chromosphere, so IRIS observations of the Mg II lines are paramount. Ideally we would like to be able to examine the perturbations from the upper photosphere into the chromosphere with IRIS. This will require observations having significant S/N in the region of Mg II k1, for example. Another constraint is spatial sampling and resolution. Ideally we would like to match the resolution of the photospheric observations with Hinode SP, which would require IRIS to observe with its full sampling of 0.33” per scan step. A likely candidate for IRIS observations is OBS ID 3620600845:

| Large dense 32-step raster 10.24x120 32s Si IV Mg II h/k Mg II w
| 65.16 | 74.10 | 0.8 | 2.0+/-0.1 | 65.2+/-0.0 | 0.0+/-0.0 | 16.3+/-0.0 | 16.3+/-0.0 | 16.3+/-0.0

This has a raster cadence of 65.2 s, covers 10”x120” at 0.33” steps with 0.33” (binned) spatial sampling along the slit, 5.4 km/s spectral sampling in the Near UV, and 11 km/s in the Far UV (x4 summing) in order to enhance the weak signals of Si IV in the quiet Sun.

Additional instrument coordination:

After the initial analysis of the observations proposed herein, we may try to extend the scope of the observations to incorporate ground-based observations of chromospheric diagnostics using instruments such as IBIS at NSO.

Previous HOP information:

HOP 79. Lites is a co-PI of the ongoing HOP 79 irradiance program. In addition to numerous oral presentations, Lites has published the following work using this extensive data set:

B. W. Lites, R. Centeno, and S. W. McIntosh, 2014: “The Solar Cycle Dependence of the Weak Internetwork Flux”, PASJ, 66 (SP1), S4.

Additional Remarks: