Topic: Jets in the Solar Atmosphere and their Effects in the Heliosphere

Project Title:
Formation and Impact of Type II Spicules

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Project Information:
We propose to study the formation and impact on the solar atmosphere of so-called type II spicules using a broad range of observations that cover all temperatures between photosphere and corona, in combination with state-of-the-art radiative 3D MHD numerical simulations of a domain encompassing the convection zone through the photosphere, chromosphere into the corona. Type II spicules are the most ubiquitous jets in the solar atmosphere with the largest potential for playing a significant role in the mass and energy balance of the corona and solar wind. We will build on our recent discovery of this novel, more violent type of spicules that appear to be associated with rapid upflows with velocities of order 50-100 km/s in the lower solar atmosphere including the transition region and corona. These upflows may be the "missing link" at the heart of the solar plasma energization quandary, and are specifically called out in the description of Focused Science Topic (c) of the TR&T Announcement of Opportunity (AO). We will investigate what role the magnetic field and photospheric dynamics play in their formation, and whether these chromospheric jets play a major role in providing the corona and solar wind with hot plasma.

We will use an arsenal of coordinated observations, covering the temperatures between photosphere and corona - including data from Hinode/SOT-EIS-XRT, SDO, Swedish Solar Telescope, and the Interface Region Imaging Spectrograph (IRIS, to be launched in December 2012). We will exploit our discovery of the disk counterpart of type II spicules (so-called rapid-blueshifted events, or RBEs) to avoid the enormous line-of-sight superposition that has plagued spicule studies at the limb for many decades. We will use already developed automated detection software to determine and develop a database of detailed properties of thousands of these jets for a variety of solar targets. We will combine these measurements with magnetic field measurements in both the photosphere and chromosphere to investigate the role of reconnection and flux emergence in the formation mechanism(s) of these jets. To gauge the impact of chromospheric jets on the corona and solar wind, we will study the association of these jets with brightenings in TR/coronal images of the footpoints of coronal loops, and with high velocity blue-wing asymmetries of TR/coronal spectral line profiles at the loop footpoints. We will exploit the presence of a weak, but significant, coronal response to chromospheric jets to provide an accurate estimate of the mass and energy flux carried into the corona by heating events associated with spicules. The observations will be rigorously compared with synthetic observables of jets from radiative 3D MHD numerical simulations (from our no-cost collaborators in Oslo) that include seed magnetic fields derived from our photospheric observations. The combined results of these investigations will help reveal how these jets form and whether they play a significant role in the heating of plasma to coronal temperatures.

The proposed research is highly relevant to the scientific goals of the Focused Science Topic (c) on Jets in the Solar Atmosphere and will be a strong contribution to the Focus Team's efforts. Our research will directly involve three of the four different types of investigations listed in the AO. We will "characterize the properties of chromospheric jets", "study the statistics of the jets and their role in providing mass and energy to the corona and solar wind", and "develop physical models of jet acceleration". We will directly advance "our understanding of the origins, structure and dynamics of chromospheric jets", and the combination of observations and modeling will lead to "models for the UV-X-ray emission from jets and their contribution to the mass and energy flux of closed and open fields in the corona and solar wind". All of these are direct measures of success outlined in the AO.

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Citations:

Summary: no summary

Citation: Judge, Philip G.; de Pontieu, Bart; McIntosh, Scott W.; Olluri, Kosovare; (2012), The Connection of Type II Spicules to the Corona, The Astrophysical Journal, Volume 746, Issue 2, article id. 158, 9 pp, doi: 10.1088/0004-637X/746/2/158

Summary: no summary

Citation: Sekse, D. H.; Rouppe van der Voort, L.; De Pontieu, B.; (2012), Statistical Properties of the Disk Counterparts of Type II Spicules from Simultaneous Observations of Rapid Blueshifted Excursions in Ca II 8542 and H?, The Astrophysical Journal, Volume 752, Issue 2, article id. 108, 14 pp, doi: 10.1088/0004-637X/752/2/108

Summary: no summary

Citation: De Pontieu, B.; Carlsson, M.; Rouppe van der Voort, L. H. M.; Rutten, R. J.; Hansteen, V. H.; Watanabe, H.; (2012), Ubiquitous Torsional Motions in Type II Spicules, The Astrophysical Journal Letters, Volume 752, Issue 1, article id. L12, 6 pp, doi: 10.1088/2041-8205/752/1/L12

Summary: no summary

Citation: Pereira, Tiago M. D.; De Pontieu, Bart; Carlsson, Mats; (2012), Quantifying Spicules, The Astrophysical Journal, Volume 759, Issue 1, article id. 18, 16 pp, doi: 10.1088/0004-637X/759/1/18

Summary: no summary

Citation: Pereira, Tiago M. D.; De Pontieu, Bart; Carlsson, Mats; (2013), The Effects of Spatio-temporal Resolution on Deduced Spicule Properties, The Astrophysical Journal, Volume 764, Issue 1, article id. 69, 5 pp, doi: 10.1088/0004-637X/764/1/69

Summary: no summary

Citation: Sekse, D. H.; Rouppe van der Voort, L.; De Pontieu, B.; (2013), On the Temporal Evolution of the Disk Counterpart of Type II Spicules in the Quiet Sun, The Astrophysical Journal, Volume 764, Issue 2, article id. 164, 14 pp, 10.1088/0004-637X/764/2/164

Summary: no summary

Citation: Sekse, D. H.; Rouppe van der Voort, L.; De Pontieu, B.; Scullion, E.; (2013), Interplay of Three Kinds of Motion in the Disk Counterpart of Type II Spicules: Upflow, Transversal, and Torsional Motions, The Astrophysical Journal, Volume 769, Issue 1, article id. 44, 11 pp, doi: 10.1088/0004-637X/769/1/44

Summary: no summary

Citation: Martínez-Sykora, Juan; De Pontieu, Bart; Leenaarts, Jorrit; Pereira, Tiago M. D.; Carlsson, Mats; Hansteen, Viggo; St ern, Julie V.; Tian, Hui; McIntosh, Scott W.; Rouppe van der Voort, Luc; (2013) A Detailed Comparison between the Observed and Synthesized Properties of a Simulated Type II Spicule, The Astrophysical Journal, Volume 771, Issue 1, article id. 66, 25 pp, doi: 10.1088/0004-637X/771/1/66

Summary: no summary

Citation:
Pereira, T. M. D.; De Pontieu, B.; Carlsson, M.; Hansteen, V.; Tarbell, T. D.; Lemen, J.; Title, A.; Boerner, P.; Hurlburt, N.; Wülse r, J. P.; Martínez-
Sykora, J.; Kleint, L.; Golub, L.; McKillop, S.; Reeves, K. K.; Saar, S.; Testa, P.; Tian, H.; Jaeggli, S.; Kankelborg, C.; (2014), An Interface Region Imaging Spectrograph First View on Solar Spicules, The Astrophysical Journal Letters, Volume 792, Issue 1, article id. L15, 6 pp, doi: 10.1088/2041-8205/792/1/L15

Summary: no summary

Citation: Rouppe van der Voort, L.; De Pontieu, B.; Pereira, T. M. D.; Carlsson, M.; Hansteen, V.; (2015), Heating Signatures in the Disk Counterparts of Solar Spicules in Interface Region Imaging Spectrograph Observations, The Astrophysical Journal Letters, Volume 799, Issue 1, article id. L3, 6 pp, doi: 10.1088/2041-8205/799/1/L3

Summary: no summary

Citation: Skogsrud, H.; Rouppe van der Voort, L.; De Pontieu, B.; Pereira, T. M. D.; (2015), On the Temporal Evolution of Spicules Observed with IRIS, SDO, and Hinode, The Astrophysical Journal, Volume 806, Issue 2, article id. 170, 10 pp, doi: 10.1088/0004-637X/806/2/170
