SUMMARY
Session H9
Surface Effects
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It is implicit in the title, "Surface Effects," of session H9 that the Sun has a surface. This term, which usually applies to the interface between a liquid or solid and a surrounding gas, plasma or near vacuum, in the case of the Sun refers to a substantial layer of gas, the solar photosphere, from which the helioseismic data HMI will transmit to earth will come. It is evident that many of the local anomalies that give rise to significant helioseismic signatures reside at or near this "surface." This session addresses the character of these signatures and their implications in seismic diagnostics, both of the Sun's surface and the underlying interior. The organizers asked seven scientists to review issues recognized as pertinent to surface effects in helioseismic research based on HMI observations. While the session organizers did not mean to promote the implication that the topics covered here are by any means exhaustive, they think these encompass a fair sample of the issues presently recognized as important to helioseismic investigations in the context of surface effects. Following are brief summaries of the individual presentations. All of the presentations were followed by a few minutes of discussion. We have not specifically included this in the summary, although this is reflected in the speakers' evaluation of the importance of the topic presented.

Excitation of Acoustic Waves by Turbulence
Mark Rast

Mark reviewed considerations that bear on the issue of how seismic waves are generated by turbulence, mostly in the few hundred km beneath the base of the photosphere. These involve the dynamics of collapse of cooling granules, the dynamics of gas flowing into the space evacuated by the granule as it accelerates downward, and the bow wave emitted by the cooled material as it descends. Mark described the dependence of the acoustic emission spectrum on parameters such as the characteristic depth at which the emission is excited with respect to the upper and lower turning points, using the analogy to organ pipe acoustics to illustrate how line profile asymmetries are diagnostic of the depth distribution of the acoustic excitation. Mark emphasized the need for both Doppler and intensity observations from the HMI.

Surface Effects Measured by Time-Distance
Junwei Zhao

Junwei Zhao reviewed studies he and Sasha Kosovichev have done on the effects photospheric magnetic fields have on time-distance diagnostics. His review was largely a summary of a paper they have recently published on this subject. He showed instances in which magnetic phase shifts in holographic signatures were significantly greater than those in time-distance diagnostics. He confirmed the basic vantage dependence of control correlation phase shifts found by Schunker et al., but showed instances in which this had no effect on models of subphotospheric sound speed anomalies. He showed instances in which masking a magnetic region had no apparent affect on the sum of the ingoing and outgoing travel time to the magnetic region from the quiet Sun many Mm away. Junwei emphasized the importance of continued study of magnetic effects notwithstanding his conviction that these would not introduce significant errors in time-distance diagnostics of flows and thermal anomalies in the subphotospheres of active regions.

Progress in Magnetohelioseismology
Ashley Crouch

Ashley reviewed theoretical models he has been working on with colleagues in Australia and Boulder of how magnetic fields interact with seismic waves. Their work has capitalized on aspects of the interation that explain absorption of p- and f-modes. The theory they have developed at length is heavily based on coupling between fast and slow magneto-acoustic gravity waves at depths at which the Alfven speed is comparable to the sound speed. Absorption of p- and f-modes can be characterized in terms of conversion of fast-mode energy to slow-mode energy by the coupling. Ash emphasized the importance of inclined fields in absorbing the p-modes, particularly the lower-degree p-modes, noting that an account for these in his MHD computations fits absorption and phase shift profiles derived from Hankel analysis remarkably well over a broad range of frequencies and horizontal wavenumbers. Ash elaborated on the relation of mode coupling to observable effects such as the dependence of the phase of the control correlations on vantage, discovered by Schunker et al. He expressed doubt that magnetically-induced phase shifts and absorption would be mitigated due to reflection of upcoming waves before the Alfven speed reached the sound speed as a general rule.

Oscillations Caused by Solar Flares
Alexander Kosovichev

Sasha reviewed work on seismic emission from solar flares, of which he and V. Zharkova discovered the first instance in the flare of 1996 July 9. Since then up to 15 other possible "sun quakes" have been reported by Alina Donea and Diana Besliu-Ionescu, of which Sasha analyzed five in detail. He confirmed the close spatial relation of the site of the seismic emission to impulsive hard X-ray emission detected by RHESSI. He reviewed the hypothesis that seismic transients from solar flares are the continuation of intense, downward-propagating shocks that result from ablation of the middle and upper chromospheric by energetic particles. Sasha emphasized the opportunity that HMI offers both for the study of flares and the use of seismic emission from flares in helioseismology.

Calibrating Helioseismic Dopplergrams of Active Regions
Richard Wachter

Richard Wachter reviewed efforts to model magnetic effects on helioseismic signatures in sunspots. Zeeman splitting of the NiI 6768 line (measured in high-resolution MDI Dopplergrams and to be similarly measured in HMI in the FiI 6173 line) results in effective broadening of the individual circularly-polarized line profiles when the magnetic field is inclined with respect to the line of sight. This results in a significantly less sensitive Doppler response in magnetic photospheres characteristic of sunspot umbrae than in the quiet Sun. The broadening of the observed line profiles is most pronounced in sunspot penumbrae if the sunspot is at disk center, because of the horizontal component of the field, resulting in a less sensitive Doppler response in penumbrae at disk center. Similarly, the sensitivity of MDI Dopplergrams at the center of a sunspot umbra (where the magnetic fields is nominally vertical) is thought to decrease significantly with increasing distance from disk center. Because of various technical ambiguities, this has yet to be confirmed by the observations. The relation between the Doppler sensitivity and the effective width of the individual circularly polarized profiles is nearly linear for MDI observations of sunspots. This result of radiative transfer computations has been confirmed by observations. This linear relation has been shown to break down for FeI 6173, for which the individual circularly polarized components are completely split by magnetic fields characteristic of sunspot umbrae (keeping in mind that FeI 6173 has a greater Lande factor than NiI 6768).

Local Helioseismology of Supergranulation and the Magnetic Network
Aaron Birch

Richard elaborated on the possibility of correcting the HMI sensitivity in sunspots by including an account for the greater effective line width in sunspots. The method he developed to correct MDI Doppler sensitivities might be adaptable to HMI in sunspot umbrae, given sufficient sampling of the line profiles to characterize fully split circularly polarized components. These considerations led to discussion later in session H9 of the practicality of sampling the line profile as thoroughly as possible at least in magnetic regions themselves. Jesper Schou explained technical practicalities that limit the spectral sampling to be implemented on the HMI. The HMI instrument will not have the on-board discrimination, for example, to treat magnetic regions preferentially.

Aaron Birch reviewed recent developments in seismic diagnostic tools designed for the quiet Sun. He gave a general review of the development of Born-approximation kernels for time-distance, holographic, and ring-diagram diagnostics, distinguishing between 2-dimensional (f-mode) and 3-dimensional (p-mode) applications. In the context of f-mode diagnostics, he reviewed work on the scattering of these by small magnetic elements, in which case the kernels show distinctive elliptical and hyperbolic fringes that characterize a medium in which waves propagate only horizontally in a horizontally uniform medium between scatterers. These fringes are clearly seen in travel-time perturbations measured by time-distance correlation techniques. He briefly mentioned the extension of the foregoing f-mode diagnostics to the applications in the scattering of f-modes to the p1-mode and the possibility of extrapolating to higher radial orders. The high-quality, concurrent Doppler, intensity and magnetic data that HMI will provide will greatly enhance both the quality and quantity of near-surface f- and p-mode scattering statistics.

Near-Surface Simulations of the Acoustic Field
Konstantin Parchevsky

Aaron also reviewed time-distance and holographic diagnostics of the supergranulation, illustrating how the horizontal scale of the supergranulation gives rise to an artifact 5–15 Mm beneath the photosphere that, somewhat diabolically, resembles signatures in previous models that have been attributed to a return of the surface outflow. Aaron emphasized the need for detailed modeling of wave progagation through supergranular-like flows as part of the HMI project.

Konstantin Parchevsky reviewed applications of numerical simulations of waves in the upper few Mm of the subphotosphere. He briefly reviewed work he has done simulating the propagation of waves from localized sources into magnetic flux tubes. In more recent simulations waves were produced stochastically outside of a circular, sourceless "magnetic region." Konstantin showed movies of the response to the magnetic region to the incoming waves both in the photosphere and in a vertical cut through the magnetic region. There are at least two considerations that bear on reduced acoustic amplitudes inside the sunspot photospheres: (i) the lack of acoustic sources inside sunspots, and (ii) the interaction of incoming acoustic waves with perturbations in photospheric pressure and density. Numerical simulations permit us to examine these considerations separately. In the simulations presented here we represent only the effects of an absence of acoustic sources in the sunspot. The background model is the same inside and outside the region representing the sunspot, but acoustic sources suppressed in the sunspot subphotosphere. The photospheric wave amplitudes were considerably smaller in the sunspot, and characterized by a considerably greater characteristic horizontal scale. Konstantin suggested that the suppression of Doppler seismic signatures in sunspots is largely a result of the lack of seismic wave generation in sunspot subphotospheres, as opposed to absorption of incoming waves, which he understands is not significant in the hydrodynamics of his sunspot. The point was made that numerical simulations would be crucial to an understanding of magnetic and other surface effects in seismic diagnostics of active regions in the term of HMI. This has clear control applications to diagnostics of active region subphotospheres.