The need for an instrument like HMI was recognized in 1996 with the conceptual design developed in 1998. The Helioseismic and Magnetic Imager is a new and improved version of the Michelson Doppler Imager (MDI) instrument on the Solar and Heliospheric Observatory (SOHO). SOHO is a joint project of the European Space Agency and NASA. MDI was developed starting in 1988 by the same collaboration between Stanford and Lockheed teams that developed HMI. SOHO was launched in December 1995. SOHO/MDI is presently still operating well and has completed helioseismic and magnetic field observation of the Sun for all of solar cycle 23 and the beginning of cycle 24. HMI will continue these important measurements from space into the next solar cycle. We hope and anticipate that HDO/SDO will enable deeper understanding of solar processes during most of solar cycle 24.

**SDO web link:** http://sdo.gsfc.nasa.gov

**HMI web link:** http://hmi.stanford.edu

**HMI/AIA JSOC data web link:** http://jsoc.stanford.edu

**HMI Major Goal Sciences**

The primary goal of the Helioseismic and Magnetic Imager (HMI) investigation is to study the origin of solar variability and to characterize and understand the Sun’s interior and the various components of magnetic activity. The HMI investigation is based on measurements obtained with the HMI instrument, one of the three instruments that make up the Solar Dynamics Observatory (SDO) mission. SDO makes measurements of the motion of the solar photosphere to study solar oscillations and measurements of the polarization in a specific spectral line to study all three components of the photospheric magnetic field. HMI produces data to determine the interior sources and mechanisms of solar variability and how the physical processes inside the Sun are related to surface magnetic field and activity. It also produces data to enable estimates of the coronal magnetic field for studies of variability in the extended solar atmosphere which is where the Earth is. Solar variability that affects the Earth is called “space weather.”

HMI observations will help establish the relationships between internal dynamics and magnetic activity. In turn this will lead to better understanding of solar variability and its effects. This will lead to reliable predictive capability, one of the key elements of the Living With a Star (LWS) program.

HMI investigation goals are to observe and understand these interlinked processes of magnetic activity and internal dynamics including:

- **Convection-zone dynamics and the solar dynamo.**
- **Origin and evolution of sunspots, active regions and complexes of activity.**
- **Sources and drivers of solar activity and disturbances.**
- **Links between the internal processes and dynamics of the corona & heliosphere.**
- **Precursors of solar activity for weather forecasts.**

**HMI Implementation**

The HMI instrument and design strategy are based on the highly successful MDI instrument with several important improvements. HMI will observe the full solar disk in the Fe I absorption line at 6173 Å with a resolution of 1 arc-second. HMI consists of a remote telescope, a polarimeter, alam imaging stabilization system, a narrow band filter, and a 4096x pixel CCD camera with mechanical shutters and control electronics. The data transfer rate is 55 Mbits/s.

Images are made in a sequence of tuning and polarizations at a 4-second cadence for each camera. One camera is dedicated to a 450 Doppler and line-of-sight field sequence while the other to a 90s field sequence. All of the images are downlinked for processing at the HMI/AIA Joint Science Operations Center at Stanford University.
The downward propagating waves are refracted upward by the temperature gradient and the upward propagating waves are reflected inward by the drop in density at the surface.

Helioseismology is the study of solar interior structure and dynamics via analysis of the propagation of waves through the Sun’s interior. The Sun is filled with acoustic waves with periods near five minutes. These waves are made by the near surface convection.

Examples of science data products from SOHO/MDI. Improved versions of these can be made with HMI observations.

- A. Sound speed variations relative to a standard solar model.
- B. Solar cycle variations in the sub-photospheric rotation rate.
- C. Solar meridional circulation and differential rotation.
- D. Sunspots and plage contribute to solar irradiance variation.
- E. MHD model of the magnetic structure of the corona.
- F. Synoptic map of the subsurface flows at a depth of 7 Mm.
- G. SOHO/EIT image and magnetic field lines computed from the photospheric field.
- H. Active regions on the far side of the sun detected with helioseismology.
- I. Vector field image showing the magnetic connectivity in sunspots.
- J. Sound speed variations and flows in an emerging active region.