## B.9 SOLAR DYNAMICS OBSERVATORY SCIENCE CENTER

### 1. Scope of Program

#### 1.1 Introduction

The launch of the Solar Dynamics Observatory (SDO), the first mission under NASA's Living With a Star (LWS) Program, will open new opportunities in solar physics. The challenges created by the unprecedented amount and cadence of scientific data from SDO will also necessitate changing the traditional approach to solar research. For example, the data stream will require developing fully automated procedures to classify various solar features using objective criteria. The SDO data pipeline will also require developing "standard" and computationally fast techniques for helioseismology to derive physical properties of magnetic fields and plasma below the photosphere with minimal human intervention.

In the past, several NASA Heliophysics research programs had supported individual projects addressing some of these elements. The goal of this solicitation is to solicit investigations that will build upon this previous research to develop the set of standard techniques, create the appropriate software, and implement this software into the SDO data pipeline. The scope of this effort requires teams of researchers with broad experience in theory/numerical simulations, observations, and data analysis. Hence, limited-scope proposals addressing only selected parts of solicited projects are not appropriate in response to this solicitation. However, such proposals can be appropriate for other Heliophysics research programs, for example the Solar and Heliospheric Physics program (see Appendix B.2) and the Heliophysics Guest Investigators program (see Appendix B.5).

Proposals on two topics are solicited: (i) the automated recognition and classification of solar features, and (ii) the development and comprehensive testing of an automated technique for local (near surface) helioseismology aimed at the derivation of the physical properties of magnetic fields below the Sun's surface and the early detection of emerging active regions. Detailed description of each topic is provided below.

#### 1.2 Automated Recognition and Classification of Solar Features

There exists a plethora of distinct features in different layers of the solar atmosphere: sunspots and active regions, filaments and prominences, coronal loops and coronal holes, coronal mass ejections (CMEs), flares, CME- and flare-related phenomena, and so forth. Traditionally, solar features were identified manually (or, in some cases, semimanually) by an observer surveying individual images and applying subjective criteria to classify the features. Over the last several years, a few researchers have attempted developing automatic procedures to identify selected solar features such as coronal holes, chromospheric filaments, sunspots, and X-ray bright points. These initial efforts suggest the feasibility of developing a universal platform to identify and classify all known solar features using an objective automated procedure.

NASA solicits proposals to develop, validate, and implement an automatic feature recognition "system" capable of identifying and classifying a variety of solar features and events.

- Proposed modules should be able to identify several, although not all, types of solar features and events. Some examples of solar features are given above, but in general, identification of any solar feature and event can be proposed. Proposals will need to provide sufficient justification for any particular set of features and events selected for identification.

- Proposed feature recognition systems should allow for the addition of future modules (for additional features and events) and the upgrade/replacement of existing modules.

- In the context of this solicitation, 'features' may also mean properties of objects or processes observed directly in solar images and magnetograms, processes in numerical models based on such observations, or patterns found in sets of otherwise determined features (including inferred associations of events -- for example, far-side helioseismic signals with active regions throughout the disk passage and the flares associated with these, or polarity-inversion lines with filament channels and CME origins).

- The modules developed should identify such features, characterize and quantify their properties, and submit that information in the Virtual Observatory Event, VOEvent, standard to the SDO/Joint Science Operations Center (JSOC) feature metadata catalog (for reference, see "Sky Events Reporting Metadata" at http://ivoa.net/internal/IVOA/IvoaVOEvent/VOEvent_v1.1.html and "A Heliophysics Knowledge Base to Facilitate Scientific Discoveries" at http://www.lmsal.com/helio-informatics/hpkb/).

- Proposers may consult the SDO instrument PI teams on the selection of the types of features to be found, the language in which the software may be coded, the interfaces to the SDO data system and feature catalogs, and the limits on the available computational resources. Details about software, data format, and interfaces can be found at SDO's Joint Science Operations Center at http://jsoc.stanford.edu and SDO Heliophysics Event Knowledgebase at http://vso.stanford.edu/hekwiki/FrontPage.

- The modules developed should be able to operate on real time data from two SDO instruments (HMI and AIA), with possible input from the other instruments (including SDO's EVE) or from other observatories using interfaces consistent with the Heliophysics Data Policy, available at http://hpde.gsfc.nasa.gov/HPDP.html).

1.3 Automated Techniques for Local (Near Surface) Helioseismology aimed at early detection of magnetic fields

Presently, there are several techniques for local helioseismology aimed at deriving the properties of plasma near the Sun's "surface" (within about 50 Mm below the photosphere). These techniques have so far focused on deriving changes in sound speed and velocity flows, but they also hold the potential to map the subsurface properties of magnetic fields and will eventually lead to predictive capabilities for the emergence and evolution of active regions. Correctly applying these techniques in and around active regions remains a challenging area of research. Recent work has clearly shown that not only the inversion methodology, but also the derivation of uncertainties and the choice of kernels, remain unsolved, and the adequacy of the key aspect of the data processing remains to be established. The validity of helioseismic derivations, especially in and around active regions, remains to be established. At present, the validity of the derivations is judged on the basis of the persistence of derived features or by comparing derivations from different instruments (e.g. Michelson Doppler Imager (MDI, http://soi.stanford.edu) and Global Oscillations Network Group (GONG, http://gong.nso.edu). Objective ways of verifying the helioseismic derivations are still in development.

NASA solicits proposals to develop and implement physics-based techniques of local helioseismology to study subphotospheric magnetic fields, thermal structures, and 3-D flows in the vicinity of mature and pre-emergent sunspots.

- The primary goal is to enable reliable measurements of subsurface flow, magnetic field, and sound speed in regions of strong magnetic fields and the assimilation of the helioseismic measurements into dynamic models of active region formation and evolution, thereby seeking to achieve predictive capability.

- The techniques should include the effects of magnetic fields on solar oscillations and a physical model for relating Dopplergrams to plasma velocities in regions of strong magnetic field.

- Once implemented, these techniques will be used as "standard" data reduction procedure in the SDO data pipeline.

- The helioseismic derivations should be quantitatively tested and verified via direct comparison with realistic numerical models of solar convection in the presence of a magnetic field. Feasibility tests should be performed to determine whether the developed techniques are sensitive enough to detect active regions prior to their emergence through the photosphere.

- The proposers may consult with the SDO/HMI instrument PI team on the language in which the software may be coded, the interfaces to the SDO data system and the limits on the available computational resources (details about

software, data format, and interfaces can be found at SDO's Joint Science Operations Center at http://jsoc.stanford.edu)

- The software should be able to operate on real time data from the SDO/HMI instrument.

2. Programmatic Information

2.1 Proposal requirements and Project Implementation

All proposals should be led by a single PI who will be responsible to NASA for coordinating the proposed effort and delivery of the final "product" (e.g. software). Limited scope collaborative proposals (separate proposals tied together by delivering common parts) will not be accepted. Proposals with multi-institution collaboration may request separate funding for participating institutional partners whose requested budget exceeds $100K per year. When separate funding is requested, the proposal should identify a lead co-investigator at each institution requesting separate funding, a statement of work, and provide a separate budget for that institutional partner.

The total award size for any proposal will not exceed $700K per year. The period of performance for selected projects is limited to no more than 4 years. The continuation of funding annually will be subject to funding availability and the annual progress of each selected project. At the end of first year, project teams will be asked to present preliminary results demonstrating the feasibility of development of the proposed techniques. Implementation of developed modules into the SDO pipeline can be done at any time during the project, but all modules should be fully integrated into the SDO pipeline and be operational upon the completion of the project. The project teams will be required to provide the final software codes and complete documentation to the SDO project soon after the individual modules have been integrated to SDO pipeline and prior to the completion of the project.

2.2 Limitations on Personnel Involved in Active Heliophysics Missions

Proposals whose intent or purpose is to duplicate or directly supplement existing investigations already funded for approved space flight missions or other Heliophysics research programs are not appropriate for this solicitation. Investigators who are members of the SDO Project teams (including PIs and Co-Is) must clearly demonstrate that the research proposed in response to this solicitation is distinct from their existing mission-related research efforts. Such personnel must include in their proposal a description of their mission responsibilities which are not to duplicate the research proposed for the SDO SC.

Owing to the larger scope of SDO Science Center proposals, the page limit for the Science/Technical/Management Section given in the *NASA Guidebook for Proposers* is increased from the default standard of 15 pages to 20 pages.

3.0 Summary of Key Information

| | |
|---|---|
| Expected annual program budget for new awards | $1.4M |
| Number of new awards pending adequate proposals of merit | 2 |
| Maximum duration of awards | 4 years. |
| Due date for Notice of Intent to propose (NOI) | June 20, 2008 |
| Due date for proposals | July 25, 2008 |
| Page limit for the central Science-Technical-Management section of proposal | 20 pp. This is an increase over the default in Chapter 2 of the *2008 Guidebook for Proposers* |
| NASA strategic objective(s) which proposals must state and demonstrate relevance to | Every proposal must address one or more strategic goal or research objectives from Table 1 in the *ROSES Summary of Solicitation*. See also Sections I(a) and IV(e) of the *ROSES Summary of Solicitation*. |
| General information and overview of this solicitation | See the *ROSES Summary of Solicitation*. |
| Detailed instructions for the preparation and submission of proposals | See the *2008 NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/. |
| Submission medium | Electronic proposal submission is required; no hard copy is required or permitted. See also Section IV of the *ROSES Summary of Solicitation* and Chapter 3 of the *2008 NASA Guidebook for Proposers*. |
| Web site for submission of proposal via NSPIRES | http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376) |
| Web site for submission of proposal via Grants.gov | http://grants.gov (help desk available at support@grants.gov or (800) 518-4726) |
| Funding opportunity number for downloading an application package from Grants.gov | NNH08ZDA001N-SDOSC |

| | |
|---|---|
| NASA point of contact concerning this program | Dr. Alexei Pevtsov<br>Heliophysics Division<br>Science Mission Directorate<br>NASA Headquarters<br>Washington DC 20546-0001<br>Telephone: (202) 358-1106<br>E-mail: Alexei.A.Pevtsov@nasa.gov |