Synoptic Solar Cycle observed by Solar Dynamics Observatory

Elena Benevolenskaya
Pulkovo Astronomical Observatory
Saint Petersburg State University

‘Differential Rotation and Magnetism across the HR Diagram’, Nordita, Stockholm, Sweden, 10 April 2013
Questions

• How the transport of the magnetic flux affect the solar cycle?

• Variability of the solar activity. What processes are responsible for these effects?

• What is the role of the coronal processes in the forming of the large-scale solar magnetic field?
Main features of the solar cycle

- 11-year sunspot cycle (Shwabe-Wolf law)
- Maunder’s Butterfly diagrams of sunspots in latitude-time coordinate system (Spörer law)
- Changing of the magnetic polarity in bi-polar complexes of solar activity (Hale's law)
- Joe’s law (about a tilt of the bi-polar regions)
Hale’s Law

Before polar reversals

Even Cycle

Odd cycle

After polar reversals
• **AIA** (Atmospheric Imaging Assembly, ultraviolet),
• **EVE** (The Extreme ultraviolet Variability Experiment, irradiance)
• **HMI** (Helioseismic and Magnetic Imager, velocity maps, magnetic field).
HMI provides four main types of data: dopplergrams (maps of solar surface velocity), continuum filtergrams (broad-wavelength photographs of the solar photosphere), and both line-of-sight and vector magnetograms (maps of the photospheric magnetic field).
<table>
<thead>
<tr>
<th>Channel name</th>
<th>Primary ion(s)</th>
<th>Region of atmosphere*</th>
<th>Char. log(T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>white light</td>
<td>continuum</td>
<td>photosphere</td>
<td>3.7</td>
</tr>
<tr>
<td>1700Å</td>
<td>continuum</td>
<td>temperature minimum, photosphere</td>
<td>3.7</td>
</tr>
<tr>
<td>304Å</td>
<td>He II</td>
<td>chromosphere, transition region</td>
<td>4.7</td>
</tr>
<tr>
<td>1600Å</td>
<td>C IV+cont.</td>
<td>transition region + upper photosphere</td>
<td>5.0</td>
</tr>
<tr>
<td>171Å</td>
<td>Fe IX</td>
<td>quiet corona, upper transition region</td>
<td>5.8</td>
</tr>
<tr>
<td>193Å</td>
<td>Fe XII, XXIV</td>
<td>corona and hot flare plasma</td>
<td>6.1, 7.3</td>
</tr>
<tr>
<td>211Å</td>
<td>Fe XIV</td>
<td>active-region corona</td>
<td>6.3</td>
</tr>
<tr>
<td>335Å</td>
<td>Fe XVI</td>
<td>active-region corona</td>
<td>6.4</td>
</tr>
<tr>
<td>94Å</td>
<td>Fe XVIII</td>
<td>flaring regions (partial readout possible)</td>
<td>6.8</td>
</tr>
<tr>
<td>131Å</td>
<td>Fe VIII, XX, XXIII</td>
<td>flaring regions (partial readout possible)</td>
<td>8</td>
</tr>
</tbody>
</table>
Sun on 9 April 2013, 6:00 - 7:00 UT

HMI, LOS

AIA 4500A

AIA 1600A

AIA 211A

AIA 094A

AIA 131A

AIA 304A

AIA 193A
AIA and HMI papers

The Atmospheric Imaging Assembly (AIA) on the Solar Dynamics Observatory (SDO)

James R. Lemen · Alan M. Title · David J. Akin · Paul F. Boerner · Catherine Chou · Jerry F. Drake · Dexter W. Duncan · Christopher G. Edwards · Frank M. Friedlaender · Gary F. Heyman · Neal E. Hurlburt · Noah L. Katz · Gary D. Kushnir · Michael Levay · Russell W. Lindgren · Dnyanesh P. Mathur · Edward L. McFeaters · Sarah Mitchell · Roger A. Rehse · Carolus J. Schrijver · Larry A. Springer · Robert A. Stern · Theodore D. Tarbell · Jean-Pierre Wuelser · C. Jacob Wolfson · Carl Yanari · Jay A. Bookbinder · Peter N. Cheimets · David Caldwell · Edward E. Deluca · Richard Gates · Leon Golub · Sang Park · William A. Podgorski · Rock I. Bush · Philip H. Scherrer · Mark A. Gummin · Peter Smith · Gary Auker · Paul Jerram · Peter Pool · Regina Souffli · David L. Windt · Sarah Beardsley · Matthew Clapp · James Lang · Nicholas Waltham

The Helioseismic and Magnetic Imager (HMI) Investigation for the Solar Dynamics Observatory (SDO)

P.H. Scherrer · J. Schou · R.I. Bush · A.G. Kosovichev · R.S. Bogart · J.T. Hoeksema · Y. Liu · T.L. Duvall Jr. · J. Zhao · A.M. Title · C.J. Schrijver · T.D. Tarbell · S. Tomczyk

Initial Calibration of the Atmospheric Imaging Assembly (AIA) on the Solar Dynamics Observatory (SDO)

Paul Boerner · Christopher Edwards · James Lemen · Adam Rausch · Carolus Schrijver · Richard Shine · Lawrence Shing · Robert Stern · Theodore Tarbell · Alan Title · C. Jacob Wolfson · Regina Souffli · Eberhard Spiller · Eric Gullikson · David McKenzie · David Windt · Leon Golub · William Podgorski · Paola Testa · Mark Weber

Polarization Calibration of the Helioseismic and Magnetic Imager (HMI) onboard the Solar Dynamics Observatory (SDO)

J. Schou · J.M. Borrelo · A.A. Napson · S. Tomczyk · D. Elmore · G.L. Card
Sine Latitude from -1.0 to 1.0
With resolution 0.001

Longitude ±15°
with resolution of 0.1°.
Cycle 24

Sunspot number

Time

AIA 193A, Carrington Rotation=CR2121

AIA 304A, Carrington Rotation=CR2121

AIA 1600A, Carrington Rotation=CR2121

17
Cycle 24

Sunspot number

Time

AIA 193A, Carrington Rotation=CR2131

AIA 304A, Carrington Rotation=CR2131

AIA 1600A, Carrington Rotation=CR2131
In the Northern hemisphere, the polar magnetic field varies close to zero and reaches the small negative values in September 2012 (CR2127), but the noticeable changing of the polar magnetic field occurs only in January 2013 within latitudinal region 60°-80° North.

In South, the situation is more complicated, The south pole is still positive for the all investigated period (May 2010-March 2013).
Nature of the solar activity and the solar cycle, correspondingly, requires a knowledge about dynamics of the magnetic field and the convection under the photosphere, the internal rotation rate, the meridional circulation with an accurate temporal and space resolution. And, of cause, it is important to investigate the coronal processes.

These problems are topical for the current and future space missions: **Hinode**, **Solar Dynamics Observatory**, **Solar Orbiter** and **Interheliozond**.