Hinode DVD for Public Outreach

Hinode Science Center, National Astronomical Observatory of Japan
PAONET Working Group for Public Use of Hinode Data

1. Introduction
   The importance of public outreach is higher than that in Yokohama and
   steadily increased until the public people get a better understanding of
   science more than before.

   People of scientific educational facilities are interested in the solar
   data. The data shows that the Sun is also an active learner. The Sun is
   the most familiar star and can be seen in the daytime. The phenomena in
   the Sun are easier to be recognized than other astronomical ones as far
   as the solar system. They can be tracked up with movies.

   “PAONET” is the association of astronomical observatories in Japan,
   including not only public astronomical observatories but also
   scientific museums and scientific educational facilities in Japan. The
   PAONET Working Group for Public Use of SOLAR Data (PAONET) was
   established by PAONET in 2003, and SOHO/MDI data was provided
to the public through the PAONET website.

   Now, according to the latest result, the solar activity shows some
   characteristics that were observed in the past. The result is the first
   attempt to select the best representative data or the best representative
   image to show the solar activity.

   The Solar Cycle of 11-year period, Japanese version DVD was published
   in March, 2008. English version was just released on 24 September,
   2008. These are the first attempt to make astronomical and scientific
   English version DVD.

2. The purpose of this DVD
   This DVD is essential to those who are engaged in SPOC activities to
   understand the Sun.

   We made two movies, both of which we expect to make the audiences to
   play another facilities for the audiences and themselves. One movie is
   the short version (10 minutes long), ideal for the public to hear the
   Sun in the daytime. Another is the long version, 15 minutes long,
   which includes the Sun of Hinode and the initial information of 3 telescopes.
   We want to see the sun in the daytime.

3. Content of the DVD
   This DVD contains 3 audio programs, "Hinode Program" and "The Sun
   Observed by Hinode".

4. Highlights of the movie
   a. Hinode Program (Short movie)
   b. The Sun Observed by Hinode (Long movie)

Contact Mr. Tonomoto (tonomot@socar.nso.nao.ac.jp) or Dr. Shimojo (shimojo@nao.ac.jp) to request the DVD after the meeting.

Please take a copy of just pressed English version DVD.
THE RELATIONSHIP BETWEEN THE MAGNETIC FIELD AND THE CORONAL ACTIVITIES IN THE POLAR REGION

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Introduction:1

Hinode shows the coronal activities around the pole.

- X-Ray Telescope (XRT) aboard Hinode showed us that numerous X-ray jets occur in the polar coronal hole.
- The occurrence rate of jets in the polar CH is 60 jets/day.

(Savcheva et al., 2007 PASJ, 59, S771)
Introduction: 2

_Hinode_ observed waves in X-ray jets

- **Two velocity components in the X-ray jets.**
  - Slow component (Ave. 200 km/s ≤ Sound speed)
  - Fast component (≥ 500 km/s ~ Alfvén speed)

  X-ray jets produce Alfvén wave or/and Alfvénic jets.
  (Cirtain et al., 2007 Science, 318, 1580)

- **The thread structures in the X-ray jets**
  - The thread structures move across the jet’s.
  (Shimojo, et al., 2007, PASJ, 59, S745)

The results suggest that waves are generated in X-ray jets.
The kG-patches and horizontal fields around the pole.

- There are intense (> 1 kG) vertical patchy magnetic fields (kG-patch) in the polar region.
  - Lifetime: 5~10 hours
- Weak horizontal fields covered the polar region.
  (Tsuneta et al., 2008, in press)

The south pole view of magnetic field strength:

- Red contours: Vertical field (>65°)
- Blue contours: Horizontal field (<25°)
Summary of the previous *Hinode* Observations

- X-ray observations of the polar region
  - Numerous X-ray jets occur in the polar CH. (60 jets/day)
  - X-ray jets generate the Alfvén waves.
    - The wave generation is very interesting from the point of view of the solar wind acceleration.
- Magnetic field in the polar region
  - There are strong patchy-magnetic fields (kG-patches) in the polar region.
  - The polar region is covered with ubiquitous weak horizontal fields.

Questions

Relationship between the strong patchy-magnetic fields (kG-patches) and the coronal structures/activities (XBP, X-ray Jets) in the polar region?


**Observation**

- **HOP02:** Polar Region Observation Campaign

- **Data**
  - SOT Filtergram
    - G-band (Photosphere)
    - Ca II H (lower Chromosphere)
    - Stokes-V of Na I [5896 Å]
      (Indicate the line of sight magnetic field)
  - SOT Spectro-Polarimeter
    - Stoke-I, Q, U, V of Fe I (Photospheric Magnetic field)
  - XRT
    - Al_poly filter image (> 2MK)
  - SOHO/EIT
    - 195Å band image (~1MK)
Result: 1
Polar Magnetic Field and Coronal Structure

- Stokes–V of Na I and Stokes–Q of Fe I

The white dashed circles indicate the relatively large kG-patches.

White: toward us
Black: toward the screen

Magnetic field on the kG-patch
**Result: 1**

**Polar Magnetic Field and Coronal Structure**

- **Stokes–V of Na I and X-ray (XRT/thin Al-poly)**

The white dashed circles indicate the relatively large kG-patches.

Co-align accuracy: ~ a few arcsec

The black dots in X-ray are not solar features. It is effect by the contamination.

**The relatively large kG-patches do not always associate with the coronal structure.**
Result: 1
Polar Magnetic Field and Coronal Structure

Stokes–V of Na I and EUV (EIT 195Å)

The white dashed circles indicate the relatively large kG-patches.

In EUV (195 and 171) image, the relatively large kG-patches do not always associate with the coronal structure, too.
Result: 2
The magnetic fields of the jet regions around the pole.

- An X-ray jet associate with EFR in the polar region

White: ⬤ toward us
Black: ✗ toward the screen

X-ray  Ca II H  Stokes-V (Na)
Result: 2
The magnetic fields of the jet regions around the pole.

- An ephemeral region in the polar region with an X-ray jet
Result:2
The magnetic fields of the jet regions around the pole.

- X-ray jets associate with cancelling flux in the polar region

White: ● toward us
Black: × toward the screen
Result: 2

The magnetic fields of the jet regions around the pole.

- The X-ray jets associate with cancelling flux in the polar region.

White: ○
  toward us

Black: ×
  toward the screen
Summary of Results

- The relation between patchy magnetic fields and coronal structures.
  - The coronal structures associated with the weak kG-patches. However, the relatively large kG-patches does not always associate with the coronal structure/activities.

- Magnetic environments of X-ray jets in the polar region
  - The jets occur above the ephemeral region (EFR) and the cancelling flux region.
    - We investigated the 8 sites that produced the X-ray jets
      - 3 sites with the magnetic enhancement (EFR)
      - 4 sites with the cancelling flux
      - 1 site is unclassified.
    - The feature is same as that of the jets around ARs.
      - The ephemeral region appear in the polar region!!
- “polar plume occur where minority-polarity flux is in contact with flux of the dominant polarity”
The magnetic environments in the polar region

Corona

TR

Chromosphere

Photosphere

EFR (Ephemeral region)

Convection

Don't make X-ray structures

Weak transient horizontal field

Relatively large Minority pole

X-ray Jet

Minority pole
Conclusion

**Observational results**

- The coronal structures associated with the (weak) kG-patches. However, **the kG-patches does not always associate with the coronal structure/activities.**

- The jets in the polar region occur above the ephemeral region (EFR) and the cancelling flux region. **The feature is same as that of the jets around ARs.**

- **The ephemeral region appear in the polar region.**

**Speculation**

- Coronal activities in the polar region are produced from the interaction of the kG-patches with the relatively large minority-polarity fluxes (EFR, cancelling flux)

- The weak transient horizontal fluxes also interact with the kG-patches, but they does not produce coronal plasma. However, the small interaction may be important from the energy input to kG patches. (Fast solar wind)

- The magnetic fields in the polar region may have two components. One is the magnetic fields come from the active region. The other one is the EFR at the polar region.
Back Up Slides
Observation

- HOP02 (old): Polar Region Observation Campaign
  - One of the core Campaigns of the Hinode project.
  - 2007/09/01 -- 28

- Dataset
  - SOT-FG (G-band, Ca II, Stokes-I and V of Na I [5896 Å])
  - SOT-SP (Stokes-I, Q, U and V of Fe I [6301.5 Å, 6302.5 Å])
  - XRT (thin Al-poly filter)

- Requirements
  - SOT : Large Field of View ( > 200” x 100”)
  - XRT : include the synoptic Images

- Selected Data
  - #06 09/06 00:22 – 07:00 : 7 hours / X-ray Jet site : 1
  - #07 09/06 18:15 – 00:00 : 6 hours / X-ray Jet site : 1
  - #14 09/10 01:10 – 06:40 : 6 hours / X-ray Jet site : 1
  - #15 09/10 15:51 – 21:30 : 6 hours / X-ray Jet site : 2
  - #39 09/16 01:17 – 07:08 : 6 hours / X-ray Jet site : 3
Result: 1
Polar Magnetic Field and Coronal Structure

Ca II H Intensity and Stokes–V of Na I

The white dashed circles indicate the relatively large kG-patches.

The kG-patches correspond with Ca bright points (and G-band BPs).

White: ⓞ toward us
Black: ⓞ toward the screen
Result: 1
Polar Magnetic Field and Coronal Structure

Stokes–V of Na I and EUV (EIT 171Å)

The white dashed circles indicate the relatively large kG-patches.

In EUV (195 and 171) image, the relatively large kG-patches does not always associate with the coronal structure, too.
Wide Field of View Movies (#06)
Wide Field of View Movies (#97)