Advanced Challenges for Communicating New Sun with Hinode Satellite

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Abstract  
Hinode is a solar observation satellite in Japan and its launch was in 2006. Since then, Hinode has been giving the unexpected view of the sun to the public, and we have communicated the new view of the sun to the public through various activities. As our impressive activity, we made a proposal that high school students co-observe the sun with Hinode. The students studied their own observational data compared with Hinode data, and had presentation on the science contests. The co-observations with Hinode draw their active motivation. The foreign astronomers have deeply interests on the proposal and the co-observations.

The use of Hinode data becomes increasingly important toward coming solar maximum. We report such activities in details.

What is "Hinode"?  
Hinode is Japanese solar observation satellite(Kosugi, T. et al. 2007, Fig.1) [1]. "Hinode" means "SUNRISE" in Japanese. Hinode was launched in September 2006. Hinode has three instruments in visible light, X-ray, and EUV wavelength onboard. With them, A goal of Hinode is to solve mystery of coronal heating and origin of solar magnetic fields and so on. Of course, Hinode is in-orbit now and still observing the sun.

Here, I introduce some recent observation results. The first image show solar corona observed with Hinode XRT(X-Ray Telescope) in September 2011(Golub, L. et al. 2007, Fig.2) . These days the solar activity is getting high. So you can find some bright active regions on the sun. The second image shows an annular eclipse observed with Hinode XRT , which was taken in its orbit on Jan 4 in 2011(Fig. 3) . This is the image released for appeal of an annular eclipse seen in Japan in May 2012. A big flare occurred on 14 February 2011. Hinode captured this big flare which occurred since 14 December 2006. The brightening regions on the image are the flare observed in CaH line of SOT(Solar Optical Telescope) on Hinode(Tsuneta, S. et al. 2008, Fig.4).
(Fig. 2) Solar corona observed with Hinode XRT (JAXA/NAOJ). This image was taken on 14 September 2011.

(Fig. 3) Annular eclipse observed with Hinode XRT in 4 January 2011 (JAXA/NAOJ)
Public Use of Hinode Data

Hinode data is very exciting and interesting, for not only investigating solar phenomena but also giving solar new figures and its knowledge to the public and the educational communities.

So, researchers want to communicate Hinode observation results to the public. But they are very busy for their research and satellite operations, other work and so on. In addition, they have low budget and no man power sparing for education and public outreach.

Educators, working in public observatories, planetariums, science museums, of course schools, want to use new Hinode observation results for planetarium program, exhibition in museums and teaching materials and communicate to the public.

So researchers and educators have collaboration each other to promote education and public outreach in Hinode. As researchers, NAOJ, National Astronomical Observatory in Japan, Hinode Science Center. As educators, PAONET Public Use of Hinode data working group described below.

We organized one working group “PAONET Public Use of Hinode Data”, which is called “PAOHINODE WG”, which started in 2006 (Yaji, K. 2008). PAONET means Public Astronomical Observatory Network, which is one of astronomical educational communities in Japan (Watanabe, J. 1998).

Now, thirteen members attend on this WG. 8 of them are educators. 5 are researchers. Researchers’ affiliations are observatories and universities, three of who worked at the educational facilities before.

We working group have been collaborating EPO Activities with Hinode Team in NAOJ in supporting money, PCs, and so on. We have 4 or 5 meetings every year and have discussions by mailing list.

For the public use of Hinode data, we working group produced and released two DVDs for introducing Hinode observation results. The first DVD "The sun Captured by Hinode" released in 2008 and introduces initial observation results of Hinode. This DVD was translated into English and released. The second DVD "Approach to Solar Mystery" released in 2009 and contains a video movie for kids. This movie was developed to a picture book in cooperation with JAXA space education center (Fig. 7).

Other activities are releasing information and topics about Hinode observation to the educational communities and developing teaching materials in schools.

As other projects, we are producing planetarium movies (Fig. 8) and an illustrated book for kids in progress.
(Fig. 5) The first DVD "The sun Captured by Hinode" released in 2008 and introduces initial observation results of Hinode.

(Fig. 6) The second DVD "Approach to Solar Mystery" released in 2009. Sorry, captions in Japanese.
Let’s Observe the Sun with Hinode! - Co-Observations with Hinode

As one advanced challenge, we are arranging co-observations with high schools and. It is positively encouraged to use Hinode data for not only research but also education. But, a fault of Hinode is not to check its observation in realtime. So, we submit a proposal to co-observe, simultaneously, with high schools, public observatories and museums. The proposal was accepted as HOP173, "EPO campaign observation mainly for high school students" [2].

As the main object, high school students who have solar observations are interested in Hinode observation data, which are promoting that they compare their own data with Hinode data. The educators develop teaching materials and use the co-observed data for exhibitions in public observatories and museums.

A proposal for the purpose of education is for the first time since Hinode’s launch. Foreign researches have high interests on the proposal and they say to us, “Good proposal”. In addition, these co-observations effect more extension of Hinode mission.

So far, we have co-observations with Hinode three times since September 2010. Last summer, co-observations were carried out from July 24 to Aug 6, 11-15h JST (2-6UT). This slot is consistent with high school students’ observation time.
As an example of the observing plan, Hinode observes one active region for 11h-13h(JST) in X-ray/Optical, takes a solar full image on 13h (JST) in X-ray and observes the same/other active region for 13h-15h (JST) in X-ray/Optical.

We must request observing plans and targets on 10:00 every morning. But, other observations, such as flare, polar region, sometimes, have high priority to our observations. Observing plans are usually uploaded three times every week.

This co-observation was appealed as "Let's Observed with Hinode!" to astronomical educational communities, of course, high school students. We invited them with a web page(Fig. 10) [3] and a leaflet (Fig. 11) made by us. As the results, eight schools, one science museum and one public observatory attended on this co-observation summer 2011. They usually have routine solar observations with visual lights, Halpha, CaK line and traditional drawing sketch.
(Fig.10) A web page introduced “Let’s observe the sun with Hinode”. Sorry, contents in Japanese.

(Fig.11) A leaflet distributed for inviting high school students. Sorry, the contents are in Japanese.
The following schools and facilities took part in the co-observation in summer 2011. The observational methods or wavelengths also are shown. WL means White light.

- Saitama University (WL, Hα, CaK)
- Keio-Gijuku High School (Hα)
- Maibara High School (WL, Hα, CaK)
- Kishiwada High School (Drawing)
- Hyogo University High School
- Shudo High School (WL, Drawing, Hα)
- Hiroshima Johoku High School (WL)
- Kobayashi-nishi High School (WL)
- Kawaguchi Science Museum (WL, Hα, CaK, Magnetic Fields)
- Nishi-Harima Astronomical Observatory (WL, Hα, CaK)

Co-observation results show from (Fig. 12-1) to (Fig. 12-10).

(Fig. 12-1) An H-alpha image taken on 25 July 2011 by Saitama University.
(Fig. 12-2) A sketch of sunspots drawn on 26 July 2011 by Kishiwada High School.
(Fig. 12-3) A white light image taken on 28 July 2011 by Kobayashi-Nishi High School.
(Fig. 12-4) A X-ray image of an active region on 25 July 2011 by XRT onboard Hinode.
(Fig. 12-5) A G-Band image of sunspots on 28 July 2011 by SOT onboard Hinode.
(Fig. 12-6) A CaH line image of sunspots on 5 August 2011 by SOT onboard Hinode.
(Fig. 12-7) An X-ray image of the full sun on 25 July 2011 by XRT onboard Hinode.
(Fig. 12-8) An X-ray image of the full sun on 28 July 2011 by XRT onboard Hinode.
(Fig. 12-9) An X-ray image of the full sun on 5 August 2011 by XRT onboard Hinode.
(Fig. 12-10) A CaK line image taken on 5 August 2011 by Maibara High School.
Case 1) Kishiwada High School: An astronomical club of this high school have continued traditional drawing sunspots since 1970. They compared their own drawing sunspots with Hinode X-ray images (Fig. 13) and investigated the relations between the sunspots and the X-ray coron. They have a presentation in the title “Drawing Sunspots compared with Hinode” in Osaka High School Geoscience Club Meeting in fall 2010.

(Fig. 13) The Hinode image is overlaid with a drawing sketch observed by Kishiwada High School students. A color image shows a solar corona taken in X-ray. Contours show a drawing sketch. It was observed on 4 September 2010.

Case 2) Kobayashi-Nishi high school: They compared their own white light images with Hinode data and research relations between sunspot and X-ray corona. They had a poster presentation on high school science contest in Miyazaki prefecture, in the title of “Solar Observations with Hinode Satellite” in fall 2011 (Fig. 14).

This way, the students have research with Hinode data and have a presentation on science contest.
After the co-observation, we had questionnaire survey for co-observers. 18 persons answered, 5 teachers, 11 students, 1 public observatory, 1 science museum. Some of questions and the results are introduced.

Q. Did you check Hinode Images?
A. 7 persons answered, "I didn’t almost check Hinode images". 11 persons answered, "I sometimes checked Hinode images". Nobody answered, "I everyday checked Hinode images".

Q. Do you want to co-observe with Hinode after this?
A. Everybody answered, “yes” or “yes, if anything”. The reasons are below.
- It was a pleasure to co-observe with Hinode and other schools.
- We can compare our data with other school’s data.
- Hinode images are very useful in the presentation of study in club activities.
- We can know what we ourselves cannot do and didn’t think.
- That makes our club more active.
- Not personal observation but co-observations by satellite with high school students make their motivation higher.(by a teacher)
Q. What do you have interests on as an object of co-observation?
A. As follows, it seems they have main interests on sunspots, prominences and solar flares.
- Sunspots       15
- Prominences  8
- Solar Flares   5
- Plage              3
- Solar Corona 2
- Granulation 1
- Others            3

Q. How did/will you use the observation data?
A. 4 persons answered they used them for comparing with their own data. 7 persons answered they used them for research presentations. A few persons used the data for teaching materials and their own study. But, 7 persons answered, “Nothing”, at time of the survey.

Q. Did your motivation get higher through this co-observation?
A. Almost persons answered, their motivation got “much higher” or ”higher” by this co-observation.

Q. What did you have impressions, demands, comments about co-observation with Hinode?
Answers are below.
- Please continue also next year.
- If possible, we would submit proposals.
- Hinode images are wonderful!!
- It was good to get new knowledge through co-observations.
- We might share our observation images each other.
- We hope following-up after observations.
- It was all I could do to take images by digital camera. Observation data, results, and summary of other schools helped our study. After this, we would research from observational data with the students toward poster presentation.
- Maling list greatly helped us.

Future Works
- We must improve how to collect /archive/apply the rich observation data obtained through these co-observations.
- Students have presentations of their study in their astronomical meetings and science contents.
- Applying the observation data to teaching materials/resources and exhibitions of museums.
- Students will use Fits Viewer Software “Makali’i” [4] and learn how to study by Hinode data.
- Students or Teachers themselves would submit a proposal that they want to observe, though I submit the observation proposals so far.
Anyway, Hinode will continue co-observations with High schools!!

Summary
We are promoting various EPO activities for public use of Hinode data since its launch. The activities are the production of DVDs, a picture book, planetarium movies, an illustrated book and developing teaching materials.
As advanced challenges for giving more interests on Hinode data to the public, we proposed and carried out co-observations with high schools and astronomical educational facilities in 2010 and in 2011. It is called “HOP173:EPO campaign observation mainly for high school students”. Such an educational proposal is the first one in Hinode, on which foreign researcher have high interests.
This proposal contributed in more extension of Hinode mission. As the results, this co-observation gave high schools/facilities high motivation on their solar observation and research activities. In future, we need to improve how to co-observe, prepare manual to get/use data, and consider how to apply archived co-observation data.

Hinode will continue co-observations with high schools!!

What is Hinode Operation Plan (HOP)?

Hinode regularly observes synoptic/full solar images twice a day and active regions in other time. But solar researchers submit a proposal and can observe the objects they want. This proposal is called Hinode Operation Plan (HOP). Now, more than 200 HOP are accepted. The observation theme (objects) are, for example, in the following:

- Polar regions, Quiet region, Prominence, Solar coronal jet
- Solar Eclipse
- Simultaneous Observations with Sounding Rocket, domestic/foreign GBO
- Helioseismology
- High temporal/spatial Observation
- Multi filter Observations

Everyone can apply to HOP and almost all HOPs are acceptable. HOP proposals are submit by 14th last month before the observation. Core scientists judge the proposal and the result turn out by 20th of the same month. But proposers have no priority for observation data, which are open and available for everyone.

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Notes