JOURNAL OF THE KOREAN ASTRONOMICAL SOCIETY
36: S155 ~ S161, 2003

EMERGENCE AND GROWTH OF SOLAR ASTRONOMY IN KOREA

HONG SIK YUN
Astronomy Program, SEES, Seoul National University, Seoul, 151-747, Korea
E-mail: yun@astrosun.snu.ac.kr

ABSTRACT

In this article I review the past and current status of solar astronomy in Korea and present some future prospects. Along with a brief historical account on the introduction of modern astronomy to Korea, I describe in detail how solar astronomy in Korea has developed since its birth about 20 years ago. With education of solar astronomers at domestic universities and collaboration with foreign scientists in China, Japan and the U. S., there has been a rapid growth of solar physics in Korea in the past decade. For further advance of solar astronomy in Korea, Korean solar astronomers have to build their own observing facilities and develop instrumentation programs. Also it is very important to bring up manpower competent for these projects.

Key words : history of solar astronomy, status, prospects, collaboration

I. A BRIEF HISTORICAL BACKGROUND

The introduction of modern astronomy to Korea dates back to 1958 when the Department of Astronomy and Meteorology was established at Seoul National University (SNU). Ten years later Yonsei University set up an astronomy program under the Department of Astronomy and Meteorology. The Korean Astronomical Society (KAS) was founded on March 21, 1965 (Yu 1976). Right after the establishment of KAS a National Committee for Korea Astronomy Observatory (KAO) was formed under the Ministry of Science and Technology in 1968. With the continuing efforts of Korean astronomers, KAO was founded in September 1974, and Sobaksan Observing Station had its opening ceremony on September 27, 1978 (Choi 1978).

Prof. Yu Kyung-Loh and Prof. Hyun Jung-June taught astronomy at SNU when I joined the department in late 1973. In 1975 the Department of Astronomy and Meteorology was split into two independent departments, Department of Astronomy and Department of Meteorology. Prof. Hong Seung-Soo joined the Department of Astronomy in 1978, Prof. Lee Sang-Gak in 1979, and Prof. Lee See-Woo in 1980. Since 1980, we have been able to deliver a variety of astronomy courses to our students. At Yonsei University, Prof. Chou Kyung-Chul had led the astronomy program for the Department of Astronomy and Meteorology until Prof. Nha Il-Seong joined the Department in 1974. Prof. Chun Mun-Suk joined the Department in 1979. PhD programs were introduced at Yonsei University in 1974 and at SNU in 1980. These two universities undertook the task of bringing up young Korean astronomers in the 1980s. The majority of students who completed their master's work in this period went abroad for their advanced studies, mostly to graduate schools in the US.

Upon the return of young astronomers who had gone abroad in the 1970s and early 1980s, Kyung Hee University established the Department of Astronomy and Space Science in 1985. In 1988, Chungbuk National University and Chungnam National University implemented astronomy programs under the name of Astronomy and Space Science. In the same year Kyungbuk National University established the Department Astronomy and Meteorology. In 1994 Pusan National University started a PhD program in astronomy. As can be seen from Fig. 1 (Yun 2003), domestic graduate programs have expanded rapidly since the early 1990s and more and more competent graduate students have decided to stay in Korea, seeking their PhD degrees at domestic universities. This trend emerged quite rapidly in the 1990s, and various fields of astronomy have been taking root in Korea during the last 10 years. At present, over 80 graduate students are pursuing their PhD studies nationwide and over 90 graduate students are studying for master's degree in diverse fields of astronomy.

Solar astronomy also followed this trend as evidenced in Fig. 2 (Yun 2003). In the figure we note that the number of papers published by Korean solar astronomers has increased rather rapidly since the early 1990s.

II. SOLAR ASTRONOMY PRIOR TO THE EARLY 1980s

During the period of the 1970s and 1980s, I carried out most of my solar research in Korea in the topic of umbral chromospheric models. This work was done in collaboration with Dr. Arne Wyller, Professor of Astronomy at the Swedish Royal Academy of Science and Dr. Herbert Beebe, Professor at New Mexico State University.

The research collaboration was initiated by Prof. Wyller who asked me to take part in the Swedish OSO-8 project in 1975. My duty was to interpret observed MgII h and k line profiles taken over sunspot umbrae

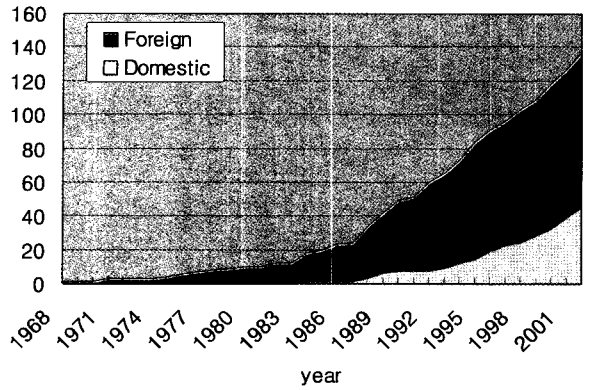

Fig. 1.— Cumulative number of Korean PhDs in astronomy. The red part refers to PhDs earned abroad and the blue part refers to domestic PhDs.

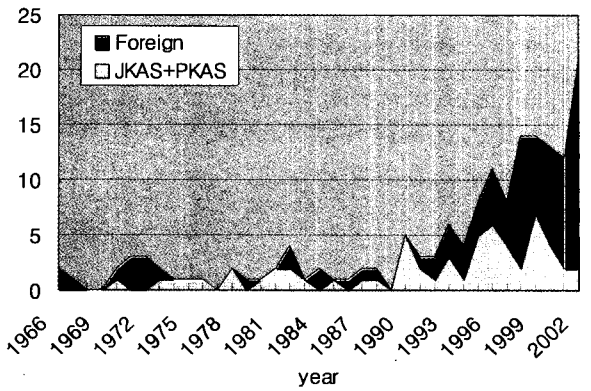

Fig. 2.— Number of papers published by Korean solar astronomers per annum. Foreign publications are mostly Ap.J. and Solar Physics among others. Domestic publications refer to Journal of Korean Astronomical Society (JKAS) and Publication of Korean Astronomical Society (PKAS).

from OSO-8. Most computations of non-LTE line profiles of MgII h and k were done at Stockholm Observatory in the summer of 1976 and at Uppsala Observatory in the summer of 1977. During this period we realized that CaII H and K lines are very important for constructing umbral chromospheric models. This led to a research collaboration with Dr. Beebe from 1979 to 1983 in which we carried out simultaneous, high resolution spectroscopic observations of CaII H, K and IR triplet lines at Sacramento Peak Solar Observatory, using the so-called HIRKHAD program. The observed spectra were taken on film and scanned by Sac Peak's fast microphotometer for analysis. Although our solar research was successful, it did not make any contribution to developing students in solar astronomy because most computations were done outside of Korea due to the lack of computing facilities in Korea at that time.

III. SOLAR ASTRONOMY AFTER THE MID 1980s

Significant progress in Korean solar astronomy was made after the mid 1980s. During this period, a number of Korean solar astronomers were produced and several international collaboration programs were carried out, which led to a rapid growth of solar research in Korea.

(a) Collaboration with Japanese Solar Astronomers

In 1983 I had an opportunity of visiting NAOJ at Mitaka for two months. The arrangement was made by Prof. F. Moriyama with support of the Yamada Foundation. During this period I visited various observatories and astronomy departments of major universities in Japan. I met a number of Japanese astronomers and became quite acquainted with their observing facilities and the Japanese astronomy community. In 1985, Prof. Unno made a visit to SNU for a month to deliver a series of lectures on 'chaos' and 'convection theory'.

Prof. Hiei visited SNU for a week in May 1989 and introduced us to three important projects: 'Solar A' later named Yohkoh, the Solar Cycle Telescope and the 1991 Solar Eclipse Expedition to Mexico. As a result, Dr. Moon Shin-Hang, then Director of KAO, became quite interested in two projects, the Solar Cycle Telescope and the 1991 Solar Eclipse Expedition. He made an important decision to install a Solar Flare Telescope (SOFT) at BOAO. Although Prof. Hiei's visit was brief, he made a great contribution to the development of Korean solar astronomy.

In February 1991, I made a visit to NAOJ with Shim Kyung-Jin, Park Young-Deuk and Lee Jong-Woong to consult with Prof. Hiei about the possibility of making a Flare Telescope for KAO. Prof. Hiei kindly showed us the detailed design of their flare telescope so that we could order a nearly identical one. The KAO finally made a contract with Dr. Wray of the 'Astrophysics' Company in September 1991 to manufacture SOFT. Three Lyot filters had already been purchased from Nanjing Astronomical Instrumental Research Center (NAIRC) in 1990. Five years later Dr. Wray installed SOFT at BOAO in May 1995. Since then, KAO has consulted Prof. Sakurai and Prof. Ichimoto for valuable information on data acquisition systems and troubleshooting technical advice for SOFT. SOFT was our first research-oriented solar instrument and became a symbol of the birth of Korean solar astronomy. With its installation, we started to have students who wanted to work on solar astronomy.

In late 1989 an eclipse team was organized in KAO to participate in the 1991 total eclipse expedition. Prof. Suematsu, head of the Japanese eclipse expedition team in 1991, was invited by KAO and SNU to come to Korea for a week to prepare our eclipse expe-

dition. The 1991 Mexico total eclipse expedition was not successful due to our lack of experience. However, the Chili total eclipse expedition in 1994, the Turkey total eclipse expedition in 1999 and the Zambia total eclipse expedition in 2001 were carried out successfully. KAO's eclipse expeditions made an important contribution to the development of solar astronomy in Korea.

It was around this time that students seeking their degrees in SNU started to join our PhD program with topics in solar physics. Park Young-Deuk, the first PhD student in solar astronomy, entered the program in 1985, Chae Jongchul in 1990, Moon Young-Jae in 1991, Kim Jung-Hoon in 1992, Lee Sang-Woo in 1995, and Bong Su-Chan in 1998. To date, Park Young-Deuk (now at KAO), Chae Jongchul (now at Chungnam National University) and Moon Young-Jae (now at KAO) have earned their PhD degrees within the program.

There are also other students who graduated from SNU and have majored in solar physics at foreign institutions. Kim Kap-Sung (now at Kyung Hee University) obtained his PhD from Kyoto University in 1987, Lee Jeongwoo (now at New Jersey Institute of Technology) from California Institute of Technology in 1993, Choe Gwangson (now at Princeton Plasma Physics Laboratory) from University of Alaska in 1995 and Shin June-Ho (now at NAOJ, Japan) from National Astronomical Observatory, Japan in 1998.

Without good observing facilities in Korea, we had to depend on the use of foreign observing facilities. Prof. Sakurai kindly allowed us to use the 25cm coronagraph and the Littrow spectrograph of Norikura Solar Observatory. Park Young-Deuk and I visited Norikura Observing Station in early August of 1992 to make spectroscopic observations of the Hα, CaII H & K, HeI 10830 and NaI D lines of solar prominences. With the use of this data, Park completed a PhD thesis entitled 'Spectroscopic Studies of Quiescent Prominences' in 1994. He became the first domestic PhD in solar astronomy.

In November 1992 we invited Prof. Sakurai to SNU to develop a plan for cooperative research using Hα and magnetogram data taken from the Solar Flare Telescope at Mitaka. To carry out this project Chae Jongchul went to NAOJ at Mitaka and analyzed observed magnetograms for 3 months. During this period he developed a new algorithm for stray light correction. He obtained his PhD in 1996 from this work with a thesis entitled 'Analysis of Solar Filter Magnetograms Using A New Algorithm For Stray Light Corrections'. The research papers that emerged from the cooperative research project with Prof. Sakurai and his associates are listed in APPENDIX under A.

(b) Collaboration with Chinese Solar Astronomers

Our relation with the Chinese solar astronomy community goes back to 1990 when I received a letter from Prof. Ye Shi-Hui. In the letter he asked me if I could send a recommendation letter to the Third World Academy of Sciences so that Prof. Hu Ju of Nanjing University could work with me at SNU for a month. She stayed with us for a month in October 1992, working on white light flare spectra. Lee Sang-Woo had a chance to analyze flare spectral data with Prof. Hu Ju. Although Prof. Hu's visit was brief, our students had the valuable experience of dealing with flare spectra.

During 2 weeks in July 1992 I was invited to Beijing Astronomical Observatory (BAO) by Prof. Li Qibin (then Director of BAO) and Prof. Wang Jia-Long. During the period I had opportunities to visit Huairou Solar Observing Station (HOSS) of BAO and the Solar Tower Observatory of Nanjing University. I met a number of Chinese solar astronomers, including Prof. Ai Guoxiang and Prof. Fang Cheng. I became quite acquainted with them and with the Chinese solar community as well. I was quite impressed with the facilities of HSOS, particularly with Prof. Ai's 9 channel magnetograph.

During this visit I had the opportunity to consult with Prof. Wang Jia-Long about the possibility of carrying out a China-Korea Cooperative Science Program through NSFC and KOSEF, using the Solar Tower of Nanjing University and the HSOS observing facilities. We agreed to submit a research proposal with the title 'Studies on Evolution of Sunspots' to NSFC and KOSEF. The main purpose of this project was to improve our understanding of sunspot evolution by examining a few long-lived sunspots and nearby active regions morphologically, spectroscopically and magnetographically from birth to final dissolution. Our proposal was approved and granted in 1993.

In November 1993 Prof. Ai and Prof. Wang visited SNU for a week to make a detailed observing plan prior to our observing visit to HSOS in the summer of 1994. In July 1994 I visited HSOS with my students Moon Yong-Jae, Kim Jung-Hoon and Yun Tae-Sam for three months to make sunspot observations. During the stay we had a chance to take a look at their archived magnetograms. Since HSOS's data archiving system was different from ours, we were not able to make full use of them. However, Dr. Moon Yong-Jae benefited most from this visit in the sense that he got interested in solar magnetic fields, which eventually led him to work on 'Flare-producing Active Regions Based on BOAO and MSO Magnetograms' for his PhD thesis.

In July 1995, I visited Nanjing University to consult with Prof. Fang for the next Cooperative Science Program. During the visit Kim Jung-Hoon and Lee Sang-Woo attempted to make spectroscopic observations of solar flares. Although they were not able to get any flare spectra because of bad weather, they had the good experience of learning how to deal with 2D solar spectroscopy. In late 1995 we submitted a cooperative research proposal entitled 'Multi-wavelength Study of Solar Flares' to NSFC and KOSEF. The proposal was approved and granted in 1996. The primary

purpose of this project was to improve our understanding of solar flares by observing them through multi-wavelength windows, using the Solar Tower of Nanjing University and HSOS observing facilities of BAO along with Yohkoh's X-ray and SOHO's ultraviolet observing data. To carry out the project, we made a visit to GSFC/NASA in 1996 for 6 months and the Solar Tower of Nanjing University in January 1999. The research papers that emerged from the China-Korea Cooperative Science Program (1993.9–1995.8, 1996.9–1998.8) are listed in APPENDIX under B.

(c) Collaboration with US Solar Astronomers

After having completed the China-Korea Cooperative Science Program we sought the possibility of research collaboration with the US. Our first attempt was to get involved in the SOHO project. In July 1995 Dr. Arthur Poland, then the U.S. Project Scientist of the SOHO project kindly invited me and two of my students, Chae Jongchul and Moon Yong-Jae to GSFC for a month. During the period Chae worked on 'Effects of Non-LTE Radiative Loss and Partial Ionization on the Structure of the Transition Region' and Moon worked on 'Coronal Temperature, Density and Non-thermal Velocity Derived from SERTS EUV Spectra'. Even though our visit was only for a month, we accomplished a lot in our research. In addition we had a good opportunity to learn how to get involved in the forthcoming SOHO project.

In April 1996 Dr. Poland invited me as a short term USRA visiting scientist at GSFC/NASA for 6 months and Chae Jongchul as a post-doctoral fellow under Dr. Poland for a year. In the first couple of months Chae developed a useful 'quick look' IDL tool, SUMER_SEARCH and SUMER_TOOL, which provides users with an easy access to SUMER data and a quick look at rough spectral characteristics. During his stay at GSFC, Chae made full use of SUMER data for his research which resulted in numerous publications in major astronomical journals.

After his post-doctoral fellowship at GSFC, Chae moved to Big Bear Solar Observatory (BBSO) in June 1997. In 1998 I made a visit to BBSO to consult with Prof. Goode, Director of BBSO about the US-Korea Cooperative Science Program through NSF and KOSEF. In September 1998 we submitted a cooperative research proposal entitled 'Solar Prominences, Flares and Magnetic Fields' to NSF and KOSEF. The primary purpose of this project was to improve our understanding of the magnetic field configurations of prominences, the magnetic field evolution associated with the formation, activation and eruption of prominences, the physical connection between prominences and flares, and the magnetic field changes associated with solar flares. The proposal was approved and granted for two years beginning in April 1999.

To carry out the project, I visited BBSO with graduate students, Kim Jung-Hoon and Lee Sang-Woo for a month or so during the summer and winter recesses each year. Mostly we made high cadence Hα images and line-of-sight magnetogram observations of prominences and flares. In the same period, Bong Su-Chan worked with Prof. Lee Jeongwoo at NJIT on developing a maximum entropy method algorithm for radio data analysis. He spent a year at NJIT in 2000 to apply the algorithm to data obtained with the frequency-agile Owens Valley Array (OVSA). At present Prof. Lee and Bong are analyzing the observed data to derive a 3D magnetic field configuration in the corona. It is expected that they will contribute a great deal to solar radio astronomy in Korea. The research papers that emerged from the US and Korea cooperative research project are listed in APPENDIX under C.

IV. FUTURE PROSPECTS

Our first research-oriented solar instrument SOFT installed at BOAO in 1995 contributed a great deal to the development of solar astronomy in Korea. With its installation students started to get interested in pursuing solar research. It may be fair to say that SOFT is a symbol of the birth of Korean solar astronomy.

In 2001 KAO produced a plan to implement a Coelostat spectrograph for solar spectroscopy, and installed it in the Dae-Duk solar observing dome in November 2002. The diameter of the Coelostat is 30 cm and the spectral resolution is about 1A/mm (0.01A/pixel). At present observing tests are underway. We expect that our second solar instrument will also give us another big impact on the development of solar astronomy in Korea.

As mentioned earlier, the solar community in Korea is still small, comprising about a dozen active solar astronomers, including those working abroad. Only three universities, Kyung Hee University, Chungnam National University and Seoul National University are offering graduate program for solar astronomy. At present more than a dozen students are seeking their degrees in these universities. On the average, one PhD in solar astronomy has been produced every two years. I, however, expect that this number will increase rapidly in the near future if the importance of the sun and the space environment is fully recognized by the Korean science communities and the relevant government authorities. Recently, Lee Jinny (Kyung Hee University) made a visit to Hiraiso Solar Terrestrial Research Center for three months in 1998 and Cho Kyung Seok (Kyung Hee University, now at KAO) for a month in 1999 to work on space weather oriented research under Dr. Akioka Maki.

Considering the small number of Korean solar researchers, research papers published by them in major journals are far more than their fraction in the entire Korean astronomical community, and the number keeps increasing. The trend will continue for the time being. In this respect I think that the future of solar astronomy in Korea is bright and promising.

Finally, I would like to emphasize that for further advance of solar astronomy in Korea, Korean solar astronomers have to make collaborative efforts in building their own observing facilities that can produce data of the best quality, either from ground or from space. For this they may need to operate instrumentation development programs, possibly in collaboration with neighboring countries. Also bringing up manpower competent for these projects is essential.

ACKNOWLEDGEMENTS

I would like to thank Su-Chan Bong for preparing figures and Arthur Poland, Gwangson Choe, Jeongwoo Lee and Jongchul Chae for reading and improving the manuscript.

REFERENCES

Choi, H. S. 1978, Congratulatory Address for Opening Sobaeksan Astronomical Observatory, The Bulletin of the Korean Astronomical Society, 3, 28

Yu, K. L. 1976, Foundation of the Korean Astronomical Society, The Bulletin of the Korean Astronomical Society, 1, 2

Yun, H. S. 2003, Memoirs — Looking Back the Years Shared With the Astronomy Department, SNU, written in Korean, in Research Work On Solar Astronomy, ed. C. Park & J. Chae (Han-Lim Publishing Company), 207

APPENDIX

A. PUBLICATION RESULTING FROM THE JAPAN AND KOREA COOPERATIVE RESEARCH PROJECT WITH PROF. SAKURAI AND HIS ASSOCIATES

1. Chae, J. C. and Yun, H. S. 1994, "Maximum Power Entropy Method for Low Contrast Images", JKAS, 27, 191–201
2. Chae, J., Yun, H. S., Sakurai, T. and Ichimoto, K. 1998, "Stray Light Correction In Magnetograph Observations Using the Maximum Entropy Method", Solar Physics, 183, 245–261
3. Chae, J., Yun, H. S., Sakurai, T. and Ichimoto, K. 1998, "Stray Light Effect On Magnetograph Observations", Solar Physics, 183, 229–244
4. Moon, Y.-J., Park, Y. D., Jang, B. H., Sim, K. J., Yun, H. S., Kim, J. H. 1996, "Data Acquisition System of the SOFT", PKAS, 11, 243–250
5. Park, Y. D., Yun, H. S., and Ichimoto, K. 1995, "Spectroscopic Analysis of Prominence Hα, CaII H&K and HeI 10830", Jour. Astrophy. & Astron. Suppl., India, 16, 384
6. Park, Y. D., Yun, H. S., Ichimoto, K., Sim, K. J. and Moon, Y. J. 1998, "Spectroscopic Study of A Quiescent Prominence", in IAU Colloquium 167, "New Perspectives On Solar Prominences", APS Conference Series, 150, 217
7. Park, Y. D., Yun, H. S., Moon, Y. J. 1998, "Spectroscopic Study of Active Prominence", PKAS, 13, 1–16
8. Park, Y. D., Yun, H. S., Moon, Y. J. 1998, "Study of Doppler Velocity Distribution in An Active Prominence", PKAS, 13, 17–30
9. Park, Y. D., Yun, H. S., Moon, Y. J. 1998, "The Spatial Sizes of Fine Structures In A Quiescent Prominence", PKAS, 13, 31–37
10. Sakurai, T. et al. 1995, "Solar flare telescope at Mitaka", PASJ, 47, 81

B. PUBLICATIONS RESULTING FROM THE CHINA AND KOREA COOPERATIVE SCIENCE PROGRAM

1. Ding, M. D., Fang, C. and Yun, H. S., 1999, "Heating in the Lower Atmosphere and the Continuum Emission of Solar White-Light Flares", ApJ, 512, pp454–457
2. Lee, S.-W., Yun, H. S. 1995, "Sunspots and Their Associated Solar Activities I. Physical Characteristics of a White Light Flare", JKAS, 28, 77–87
3. Lee S. W., Yun, H. S., Moon Y. J., Wang J. L. 1996, "Evolution of Sunspots Based on Vector Magnetogram and H-alpha Filtergram Observation", JKAS, 29, 9–18
4. Lee, S. W., Lee, J. W., Yun, H. S., Fang, C., J. Hu 1996 "Time-Dependent Flare Signature in Hydrogen Balmer Lines" ApJ. 470, L65–L68
5. Lee, S. W., Yun, H. S., J. Hu, Fang, C., Wang, J. L. 1996, "Spectral Analysis of Hα, Hβ and Hγ Lines of a White-Light flare(3B/X6.1) on October 27, 1991", Solar Physics, 163, 361–370
6. Moon, Y.-J., Yun, H. S., Park, Y. D. 1996, "Alternative Flare Activity Indicator: MAD", JKAS, 29, S323–S324
7. Moon, Y. J., Yun, H. S., Park, J. S. 1998, "Revisit to Schluter-Temesvary Self-similar Sunspot Models", ApJ, 494, 851–857
8. Moon, Y. J., Park, Y. D., Yun, H. S., 1999, "Calibration of Vectormagnetograms by Solar Flare Telescope of BOAO", JKAS, 32, 65–73
9. Moon, Y. J., Park, Y. D., Yun, H. S., Cho, E. A. 1999, "Study of Solar Active Regions Based on BOAO Vectormagnetograms" JKAS, 32, 127–136
10. Moon, Y. J., Yun, H. S., Lee, S. W., J. H. Kim, Choe, G. S., Park, Y. D., G. Ai, H.Q. Zhang and Fang, C., 1999, "A Measure of Magnetic Field Discontinuity", Solar Physics, 184, 323–328

11. Wang, J. L., and Yun, H. S. 1995, "Study of Solar Activity in Solar Terrestrial Systematology", Progress in Geophysics, 10, 23–34
12. Wang, J. L., Zhang, Q., Ma, G., Yun, H. S. 1996, "Sunspot Motions Associated with the 3B/X1.5 Solar Flare of 13 May 1981", JKAS, 29, 217–221
13. Wang, J. L., Yun, H. S., 1997, "A Comparison of the 3B/X3.0 Flare of February 4 with the 3B/X1.7 Flare of February 6, 1986 and the Related Disturbances", Workshop on Flares and Related Disturbances, pp44–47
14. Yoon, T.-S., Yun, H. S., Kim, J.-H., 1995, "Dynamical Characteristics of Sunspot Chromosphere II. Analysis of CaII H & 8498 Lines of Sunspot(SPO 5007) for Oscillatory Motions", JKAS, 28, 245–253
15. Yun, H. S., Lee, S. W., Lee, J. W., Fang, C., Hu, J., Wang, J. L., 1997, "Time Dependent Change of Hydrogen Balmer Lines of a White Light Flare (3B/X6.1) on 27, October 1991", Workshop on Flares and Related Disturbances, pp67–70

C. PUBLICATIONS RESULTING FROM THE US AND KOREA COOPERATIVE RESEARCH PROJECT

1. Chae, J., Yun, H. S., Poland, A. I. 1997 "Effects of Non-LTE Radiative Loss and Partial Ionization on the Structure of the Transition Region", ApJ, 480, 817–824
2. Chae, J., Yun, H. S., Poland, A. I. 1998, "Temperature Dependence of UV Line Average Doppler Shifts in the Quiet Sun", ApJ Suppl. 144, 151–164
3. Chae, J., Wang, H., Lee, C.Y., Goode, P. R., Schuehle, U. 1998, "Photospheric Magnetic Field Changes Associated with Transition Region Explosive Events", ApJ, 497, L109
4. Chae, J., Wang, H., Lee, C.Y., Goode, P. R., Schuehle, U. 1998, "Chromospheric Upflow Events Associated with Transition Region Explosive Events", 504, L123
5. Chae, J., Denker, C., Spirock, T. J., Wang, H., Goode, P. R. 2000, "High-Resolution Hα Observations of Proper Motion in NOAA 8668: Evidence for Filament Mass Injection by Chromospheric Reconnection", Solar Physics, 195, 333
6. Chae, J., Qiu, J., Wang, H., Goode, P. R. 1999, "Extreme-Ultraviolet Jets and Halpha Surges in Solar Microflares", 513, L75
7. Chae, J., Wang, H., Goode, P. R., Fludra, A., Schuehle, U. 2000, "Comparison of Transient Network Brightenings and Explosive Events in the Solar Transition Region", 528, L119
8. Chae, J., Wang, H., Qiu, J., Goode, P. R., Wilhelm, K., 2000, "Active Region Loops Observed with SUMER on Board the SOHO", 533, 535
9. Chae, J., Martin, S. F., Yun, H. S., Kim, J. H., Lee, S. W., Goode, P. R., Spirock, T. J. and Wang, H. 2001, "Small Emerging Magnetic Bipoles in a Filament Channel", ApJ, 548, 497
10. Chae, J., Wang, H., Qiu, J., Goode, P. R., Strous, L. and Yun, H. S. 2001, "Formation of a prominence in active region NOAA 8668: 1. SOHO/MDI observations of magnetic field evolution", ApJ, 560, 476
11. Chae, J., Moon, Y. J., Wang, H. and Yun, H. S., 2002, "Flux cancellation rates and converging speeds of cancelling magnetic features", Solar Physics, 207, 73
12. Chae, J., Park, Y. D., Moon, Y. J., Wang, H. and Yun, H. S. 2002, "Temperatures of Extreme-Ultraviolet-Emitting Plasma Structures Observed by the Transition Region And Coronal Explorer", ApJ, 567, L159
13. Kim, J. H., Yun, H. S., Lee, S. W., Chae, J. and Goode, P. R. and Wang, H. 2001, "A Rapid Change in Magnetic Connectivity Change Observed Before A Filament Eruption and Its Associated Flare", ApJ, 547, L85
14. Lee, J. W., J. C. Chae, Yun, H. S., Zirin, H. 1997 "Power spectra of Solar Network and Non-network Fields", Solar Physics, 171, 269–282
15. Lee, J. W., J. C. Chae, Yun, H. S., Zirin, H. 1997 "The effect of seeing on Solar Magnetic Flux Measurements", Solar Physics, 171, 35–48
16. Moon, Y. J., Yun, H. S., Davila, J. M., Park, Y. D. 1996, "Coronal Temperature, Density and Nonthermal Velocity Derived from SERTS EUV Spectra", JKAS, 29, 207–215
17. Moon, Y. J., Choe, G. S., Yun, H. S. and Park, Y. D. 2000, "Flaring Time Interval Distribution and Spatial Correlation of Major X-ray Solar Flares", The 2000 Space Weather week Conference(5. 1. – 5. 5, 2000), Space Environment Center, NOAA, Boulder Colorado
18. Moon, Y. J., Choe, G. S., Yun, H. S. and Park, Y. D. 2001, "Flaring Time Interval Distribution and Spatial Correlation of Major X-ray Solar Flares", JGR Space Research, 106, A12, 29951
19. Moon, Y. J., Chae, J., Choe, G. S., Wang, H., Park, Y. D., Yun, H. S., Yurchyshyn, V. and Goode, P. R. 2002, "Flare activity and magnetic helicity injection by photospheric horizontal motions", ApJ, 574, 1066
20. Moon, Y. J., Choe, G. S., Park, Y. D., Wang, H., Gallagher, P. T., Chae, J., Yun, H. S. and Goode, P. R. 2002, "Statistical evidence for sympathetic flares", ApJ, 574, 434
21. Moon, Y. J., Choe, G. S., Park, Y. D., Wang, H., Gallagher, P. T., Chae, J., Yun, H. S. and Goode, P. R. 2002, "Statistical evidence for sympathietic flares", ApJ, 574, 434

22. Moon, Y. J., Choe, G. S., Yun, H. S., Park, Y. D. and Mickey, D. L. 2002, "Force-freeness of solar magnetic fields in the photosphere", ApJ, 568, 422

23. Moon, Y. J., Choe, G. S., Wang, H., Park, Y. D., Gopalswamy, N., Yang, G., and Yashiro, S. 2002, "A statistical study of two classes of coronal mass ejections", ApJ, 581, 694

24. Moon, Y. J., Chae, J., Wang, H., Choe, G. S., and Park, Y. D. 2002, "Impulsive variations of magnetic helicity change rate associated with eruptive solar flares" ApJ, 580, 528

25. Moon, Y. J., Wang, H., Spirock, T., and Park, Y. D. 2002, "Temporal change of magnetic shear free from the 180 degree ambiguity", JKAS, 35, 143

26. Park, Y. D., Moon, Y. J., Kim, J. and Yun, H. S. 2002, "Delay times between geoeffective solar disturbances and geomagnetic indices", Astrophysics and Space Science, 279, 343

27. Yun, H. S., Chae, J. C., Poland, A. I. 1996, "Responses to the Transition Region to Downward and Upward Flows", JKAS, 29, S339–S340

28. Yun, H. S., Chae, J. C. and Poland, A. I., 1998, "Dynamical Characteristics of the Quiet Transition Region: Spatial Correlation Studies of H I 931 and S VI 933 UV Lines", JKAS, 31, 1

29. Yun, H. S., 1999, "Solar Activity and Space Environment", 1999, PKAS, 14, 83–89

30. Yun, H. S., Moon, Y. J., Park, Y. D. and Choe, G. S. 2000, "Correlation Studies Between Geoeffective Solar Origins and Geomagnetic Indices", The 2000 Space Weather week Conference(5. 1. – 5. 5., 2000), Space Environment Center, NOAA, Boulder Colorado

31. Yun, H. S., Lee, S., Chae, J., Choe, G. S., Kim, J. H., Park, Y. D., Goode, P. R. and Wang, H. 2002, "Dip-like Magnetic Structure Seen in Solar Prominences", Proceedings of COSPAR Colloquium Beijing 2001, 103