

FINAL REPORT of the Training-Workshop on “A Data Analysis Workshop on Coronal Mass Ejections and Solar Radio Bursts: Coronal and Interplanetary Shocks”

(GG Abraha, Mekelle University)

Introduction

Shock waves represent a universal process from the solar corona to the heliospheric termination shock and supernova shocks to shocks in the intergalactic medium. Super Alfvénic Coronal Mass Ejections drive shock which can in turn produce type II bursts. These type II bursts can help us to remotely probe CMEs for better for better modeling of CMEs as CMEs play major role in space weather. Spacecraft such as the Solar Heliospheric Observatory (SOHO), the Solar Terrestrial Relations Observatory (STEREO), Wind, and the Advanced Composition Explorer (ACE) missions routinely pass through shocks driven by these CMEs in the interplanetary medium and thus provide excellent details on the shock properties and the energetic particles contained in them. While these in situ measurements are extremely valuable, more important is the origin of these shocks very close to the Sun – typically only about 350,000 km above the solar surface. Such shocks have to be observed remotely using ground based radio telescopes in the form of type II radio bursts. Early detection of these shocks is also important because they cause particle increase at Earth during their Earth arrival and sudden commencement of geomagnetic storms. One of the simple radio instruments capable of observing solar radio bursts is the Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory (CALLISTO) deployed worldwide by ETH Zurich. There is a concentration of these instruments in East Africa – South Asia region that acquire valuable data on solar radio bursts. Thus a workshop to combine the radio and coronagraph data to study solar eruptions is highly valuable in getting a large number of young people trained in this field so they can make important contributions to the study of Sun-Earth connection. This instrument was installed at Mekelle University building and now is collecting data and this data is available online.

The Scientific objectives:

The main objectives of the workshop are:

- Enabling MSc, PhD students and young researchers to be able to analyze space-based white-light coronagraph observations, Shock signatures at 1AU and radio spectral observations from space and ground.
- After the workshop, the participants will be able to perform correlative data analysis on coronal mass ejections and shocks, thus contributing to the progress of this important field in Sun-Earth connection.
- Improving our understanding of the origin of energetic particles in the heliosphere in association with coronal mass ejections (CMEs) and Corotating interaction regions

(CIRs) propagation and evolutions

- To install e-Callisto instrument and make the data available on line and use for research applications

Main Organizers:

Nat Gopalswamy, NASA Goddard Space Flight Center, USA (nat.gopalswamy@nasa.gov)

Gebregiorgis Abraha, Mekelle University, Ethiopia (ggabraha@yahoo.com.hk)

Christian Monstein, ETH Zürich, Switzerland (monstein@astro.phys.ethz.ch)

Date and Venue: The training-workshop took place on 20-25/February 20017 at the Mekelle University and partly at Axum Hotel in Mekelle City, around the Northern part of Ethiopia. The training team arrived at the Venue one day before, on 19 February 2017.

Lecturers

The members of the training team were Prof. Nat Gopalswamy, Dr. Seiji Yashiro, Dipl. Ing. Christian Monstein, Dr. Ebenezer, *Dr. C.Kathiravan*, Dr. Gebregiorgis Abraha, Dr. Tsegaye Kassa, Dr. Tsega Berhane.

Students and Lecturers

There were 39 students and lecturers in the workshop. Out of these 7 students were from Africa excluding Ethiopia, 2 from USA, 1 from Europe, 4 from India and the rest are from Ethiopian Universities. The detail list is presented below.

<i>No</i>	<i>Name</i>	<i>University/institution</i>	<i>country</i>	<i>e-mail</i>
1	<i>Dr Tsegaye kassa</i>	<i>Bahirdar University</i>	<i>Ethiopia</i>	<i>tsegaye8684@gmail.com</i>
2	<i>Aklilu Getachew</i>	<i>MU</i>	<i>Ethiopia</i>	<i>aklilug2000@yahoo.com</i>
3	<i>Mulugeta Melaku</i>	<i>A.A University</i>	<i>Ethiopia</i>	<i>mmulugeta23@yahoo.com</i>
4	<i>Melat Aradom</i>	<i>MU</i>	<i>Ethiopia</i>	<i>aredom.miliat3@gmail.com</i>
5	<i>Teshome Dugassa</i>	<i>E.O</i>	<i>Ethiopia</i>	<i>tdugassa2@gmail.com</i>
6	<i>Fikadu Demissie</i>	<i>E.O</i>	<i>Ethiopia</i>	
7	<i>Semere Redae</i>	<i>Axum University</i>	<i>Ethiopia</i>	<i>semereredehei@yahoo.com</i>
8	<i>Henok Giday</i>	<i>Adigrat University</i>	<i>Ethiopia</i>	<i>henigidey2@gmail.com</i>
9	<i>Habtamu G/mariam</i>	<i>Axum University</i>	<i>Ethiopia</i>	<i>haftamu0914@yahoo.com</i>
10	<i>Dereje Getachew</i>	<i>University of Gondr</i>	<i>Ethiopia</i>	<i>deregeta06@gmail.com</i>
11	<i>Roma Kassie</i>	<i>Mekelle University</i>	<i>Ethiopia</i>	<i>Romakassie389@gmail.com</i>

12	<i>Abraha G/medhin</i>	<i>Mekelle University</i>	<i>Ethiopia</i>	<i>z.ab2116@gmail.com</i>
13	<i>Dr.Tsega Berhane</i>	<i>Mekelle University</i>	<i>Ethiopia</i>	<i>tsegaphysic@yahoo.com</i>
14	<i>Dr.G/giorgis Abraha</i>	<i>Mekelle University</i>	<i>Ethiopia</i>	<i>ggabraha@yahoo.co.hk</i>
15	<i>Tekie Aregay</i>	<i>Mekelle University</i>	<i>Ethiopia</i>	
16	<i>Mpho Tshisaphungo</i>	<i>SANSA</i>	<i>South Africa</i>	<i>mtshisaphungo@sansa.org.za</i>
17	<i>Sarathiel Tuyizere</i>	<i>Kigali University of Rwanda</i>	<i>Rwanda</i>	<i>salatuy@gmail.com</i>
18	<i>Umuhire Ange Cynthia</i>	<i>Kigali University of Rwanda</i>	<i>Rwanda</i>	<i>angelaciany@gmail.com</i>
19	<i>Prof. Rajmal Jain</i>	<i>Kodaikanal Solar</i>	<i>India</i>	<i>rajmal_9@yahoo.com</i>
20	<i>Dr. Kelali Adhona</i>	<i>Ministry of S&T</i>	<i>Ethiopia</i>	<i>atkelali@gmail.com</i>
21	<i>George Ochieng</i>	<i>Maseno University of Kenya</i>	<i>Kenya</i>	<i>georgeochieng08@yahoo.com</i>
22	<i>Khaled Ali</i>	<i>Swmc Egypt</i>	<i>Egypt</i>	<i>khaledega@googlemail.com</i>
23	<i>Gebrehiwot Markos</i>	<i>Mekelle University</i>	<i>Ethiopia</i>	<i>jerrymarkos@yahoo.com</i>
24	<i>Dr. C. Ebenezer</i>	<i>Institute of Astrophysics Kodaikanal</i>	<i>India</i>	<i>eben@iiap.res.in</i>
25	<i>Mr. Patel Mayank</i>	<i>Kodaikanal Solar</i>	<i>India</i>	<i>patelmontu6268@gmail.com</i>
26	<i>Dr. C.Kathiravan</i>	<i>Indian Institute of Astrophysics</i>	<i>India</i>	<i>kathir@iiap.res.in</i>
27				
28	<i>Dr. Seiji Yashiro</i>	<i>The catholic University of America,</i>	<i>U.S.A</i>	<i>seiji.yashiro@nasa.gov</i>
29	<i>Prof Nat Gopalswamy</i>	<i>U.S.A</i>	<i>NASA</i>	<i>n_gopalswamy@yahoo.com</i>
30	<i>Dipl. Ing. Christian Monstein</i>	<i>ETH Zurich</i>	<i>Switzerland</i>	<i>monstein@astro.phys.ethz.ch</i>
31	<i>Martin Mule Mutie</i>	<i>Nairobi University</i>	<i>Kenya</i>	<i>martmulesh@yahoo.com</i>
32	<i>Glober Meshack</i>	<i>Nairobi University</i>	<i>Kenya</i>	
33	<i>Samuel Seyoum</i>	<i>Weldia University</i>	<i>Ethiopia</i>	<i>samisiym@gmail.com</i>
34	<i>Yikdem Mengesha</i>	<i>EO</i>	<i>Ethiopia</i>	<i>Yikdema16@gmail.com</i>
35	<i>Nigus Alene</i>	<i>MU</i>	<i>Ethiopia</i>	<i>nigus_alene@yahoo.com</i>
36	<i>Hailay T/giorgis</i>	<i>MU</i>	<i>Ethiopia</i>	<i>haiphysics@yahoo.com</i>
37	<i>Tesfasliassie</i>		<i>Ethiopia</i>	<i>tesfay_14@yahoo.com</i>

	Ykuno			
38	Abebe Tadesse	<i>MU</i>	<i>Ethiopia</i>	<i>abebetadesse2@gmail.com</i>
39	Dr. Hagos Aregay	<i>MU</i>	<i>Ethiopia</i>	<i>hagos.aregaya@gmail.com</i>

The Training Workshop

The Program was started on 17 February 2017 by installing the e-Callisto instrument. The installation was led by Prof. Rajmal Jain and Christian Monstein The actual workshop was inaugurated on day 20 February 2017.

The workshop was opened by Dr. Gebregiorgis Abraha by announcing the programs of the workshop and invited to Dr. Habtu Alemayohu to make the welcoming speech. Dr. Habtu Alemayehu, Dean of the College of Computational and Natural Sciences, welcomed and briefed the participants on the endeavors of his college towards the development of science in general and space science in particular.



Prof. Nat Gopalswamy, from NASA Goddard Space Flight Center, USA



MU's Vice President for Academics, Dr. Abdulkadir Kedir, making an opening speech



Dr. Habtu Alemayehu, Dean of the College of Computational and Natural Sciences, making a welcoming speech



Dr Gebregiorgis Abraha, The Head of the Department of Physics, introducing the proceedings of the workshop

Mekelle University's Vice President for Academics, Dr. Abdulkadir Kedir, then made an opening speech accentuating the commitment of the top management of the university to support and build on the outputs of such international workshops. A Keynote speech by Prof. Nat Gopalswamy, from NASA Goddard Space Flight Center, USA, and the Executive Director of ISWI, highlighted the importance of ground based observations that can be effectively combined with the coronagraph data from space missions. Another keynote speech was also made by him on Solar Radio Astronomy.

Other lecturers talked about Studies of the Sun using Radio Dynamic Spectra, Catalog of Dynamic Spectra, Geomagnetic Storms and their influences on Magnetosphere and Ionosphere Regions, Ionospheric irregularities over Bahir Dar, Ethiopia during selected geomagnetic storms, the SOHO/LASCO CME Catalog and web-based analysis tools, Statistical Relationship between Solar flares and CMEs, Radio physics of the Sun, Radio Observations of CMEs and associated phenomena, and Hierarchical Relationship of pure DH, m-DH and DH-km type II bursts using the kinematic properties of the associated CMEs.

Dr. Kelali Adhana, the Director of the East African Regional Office of Astronomy for Development (ROAD), called for innovation and development in space industry in Africa and particularly emphasizing the need to unlock the deep-seated knowledge in Ethiopian monasteries and ancient churches in relation to Astronomy and Space Science.

Issues Addressed in the workshop

The workshop was lively, interactive, and highly effective in exchanging information on CMEs and radio bursts. Students were highly motivated and everyone actively participated and the lecturers also effectively used their time in training how to analyze data from SOHO, STEREO, Wind, SDO and e-CALLISTO. The students also learned and how data is analyzed using Python.



Dipl. Ing. Monstein talking about retrieving CALLISTO data

The training program had two components

- I. Oral presentation: The first two days, all the lecturers presented their presentation. The presentation covered from the Sun to Earth, including Space Weather.
- II. The second part of the workshop was covered in three days focusing on Python program and data analysis techniques from different instruments. The python training was provided by Christian Monstein and the data analysis training was provided by Nat Gopalswamy, Seiji Yashiro and Christian Monstein. The training was very effective and the students were highly motivated. They are now ready to do research by analyzing data from SOHO and e-CALLISTO for further publication.
- III. Future plans and research collaboration were discussed among the lecturers.

Problems Encountered and Solutions

The training workshop was smoothly conducted except for a few power interruptions. Using backup generators the power interruption was amended and finally the venue of the workshop was changed to another location to avoid these drawbacks.

Conclusion and Future work

The workshop deliberations involved the nature of the Sun and its impact on Earth, general astronomy, radio astronomy, solar astronomy, and about different instruments that provide data on these topics. In a quest to understand CME origin and evolution, it was necessary to understand the difference between type II and type III radio bursts. Participants understood that the behavior of these bursts and were able to differentiate them. The association between CME and type II bursts was investigated thoroughly using specific events. Relevant to shock propagation, an important insight was discussed regarding the coronal Alfvén speed profiles. It was also made clear that the fastest CMEs drive shocks. Furthermore there were several scientific discussions between the scientists and the participants which opened the door for further collaboration in the areas of the theme. The workshop provided a great opportunity for collaboration among different institutions of the world. A new instrument was also deployed in the Mekelle University and is operational now. Another workshop is also planned to conduct next year by broadening the theme of the workshop.



Participants gathered near the CLLISTO antenna



CALLISTO antenna at the roof top in Mekelle University

The overall program of the workshop

Date	Time	Program Activities	Responsible	Facilitator/moderator
20 Feb 2017	9:00-9:10	Program Announcement	Dr. Gebregiorgis A.	
	9:11-9:20	Welcome speech	Dr. Habtu Alemayehu, Dean of CNCS	Dr. GG Abraha
	9:21-9:30	Opening Speech	Dr. Kindeya G/hiwot, President of MU	Dr. Habtu Alemayehu
	9:31-10:00	Keynote Speech	Prof. Nat Gopalswamy NASA Goddard Space Flight Center, US	Dr. GG Abraha
	10:01-10:20	Keynote Speech	Dr. Kelali Adhana, ER-	Dr. GG Abraha

			ROAD	
	10:21-10:45	Health Break	Organizers	
	10:46-11:05	Introduction to Solar Radio Astronomy	Dr. Ebenezer	Dr. Hagos W.
	11:06-11:25	Studies on Sun using Solar Dynamic Spectrograph	Dr. Ebenezer	
	11:26-11:45	Catalog of Dynamic spectra	Dipl. Ing. Monstein	
	11:46-12:30	Discussion		
	12:31-14:00	Lunch Break	Organizers	
	14:01-14:30	Geomagnetic Storms and their influences on Magnetosphere and Ionosphere Regions	Dr. GG Abraha	Dr. Kelali A.
	14:31-15:00	Ionospheric irregularities over Bahir Dar, Ethiopia during selected geomagnetic storms	Dr. Tsegaye Kassa	
	15:01-15:20	Discussion		
	15:21-15:45	Health Break		
	15:46-16:00	Wrap up of Day	Dr. GG Abraha	
	16:00-18:00	Free Time		
	18:00 --	Reception		
21 Feb. 2017	9:00-9:30	The SOHO/LASCO CME catalog and web-based analysis tools	Dr. S. Yashiro	

				Prof. Rajmal Jain
	9:31-10:00	Statistical Relationship between Solar flares and CMEs	Dr. S. Yashiro	
	10:01-10:30	Discussion		
	10:31-10:45	Health Break	Organizers	
	10:45-11:15	Radio physics of the Sun	Dr. C. Kathiravan	
	11:15-11:45	Radio observations of CMEs and associated phenomena	Dr. C. Kathiravan	Prof. Nat Gopalswamy
	11:46-12:30	Discussion		
	12:31-14:00	Lunch Break	Organizers	
	14:01-14:30	Hierarchical Relationship of pure DH, m-DH and DH-km type II bursts using the kinematic properties of the associated CMEs	Dr. Tsega Brihane	Dr. Ebenezer
	14:31-15:00	Python	Dipl. Ing.Monstein	
Feb 22-25, 2017		Training	Prof. Nat Gopalswamy, Dr. S. Yashiro and Dipl. Ing.Monstein	

Acknowledgement:

On the Behalf of IOC and LOC we will like to acknowledge the following

1. Mekelle University Management
2. COSPAR
3. SCOSTEP
4. International Space Weather Initiative (ISWI)
5. Adigrat University
6. Axum University
7. All lecturers