

*The solar corona is an unusual
mechanical system, constructed
mainly out of magnetism*

***Do we need scientific observations
during total solar eclipses ?***

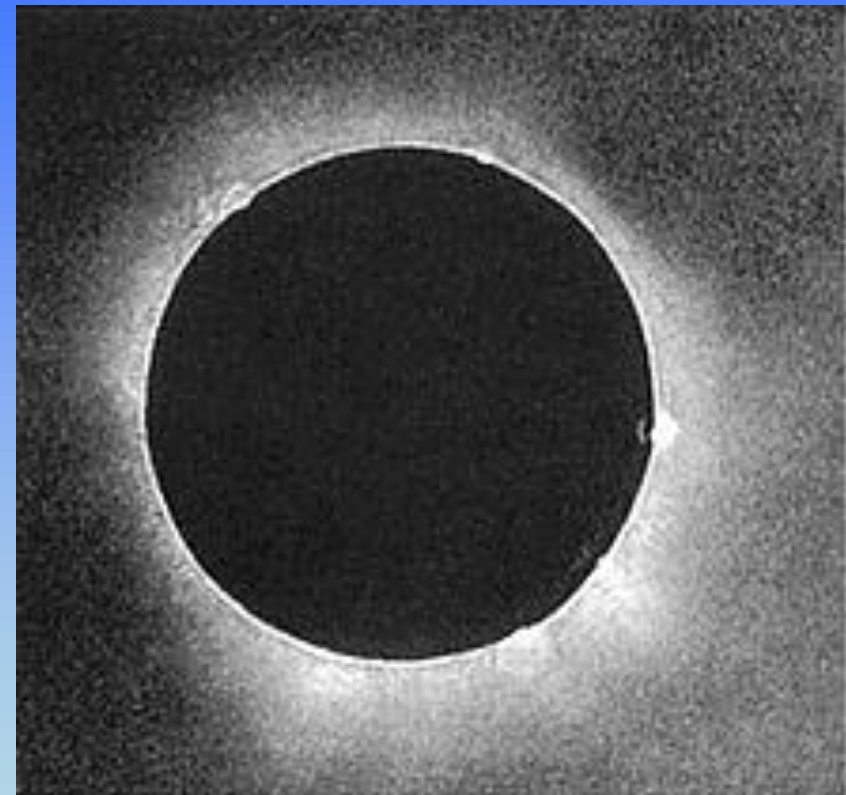
**Vojtech Rusin
Astronomical Institute
Slovak Academy of Sciences
059 60 Tatranská Lomnica
The Slovak Republic
(vrusin@ta3.sk)**



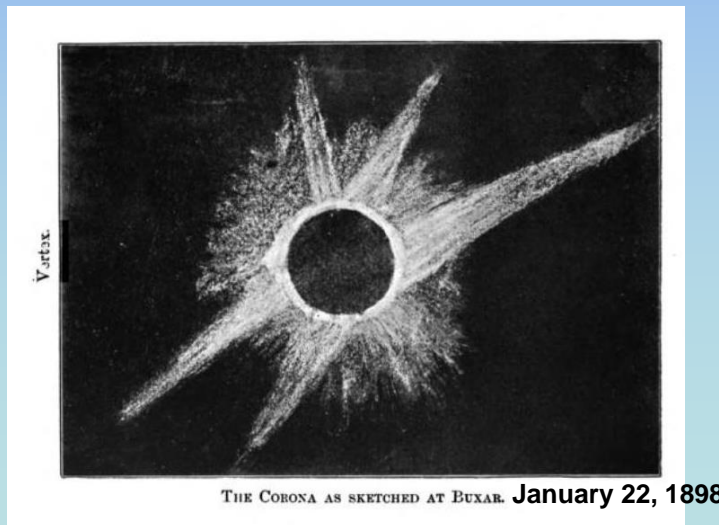
Content

- The solar corona from the past (milestone in the eclipse research) to present
- **Present status of the solar corona from eclipse observations**
- **Problems to be solved in the future during total solar eclipses**

The solar corona (in past)



First photography of the solar corona,
taken by Berkovski, on July 28, 1851
(Konigsberg/Kaliningrad
Exposure 84 sec, daguerretype)



The solar corona (at present)



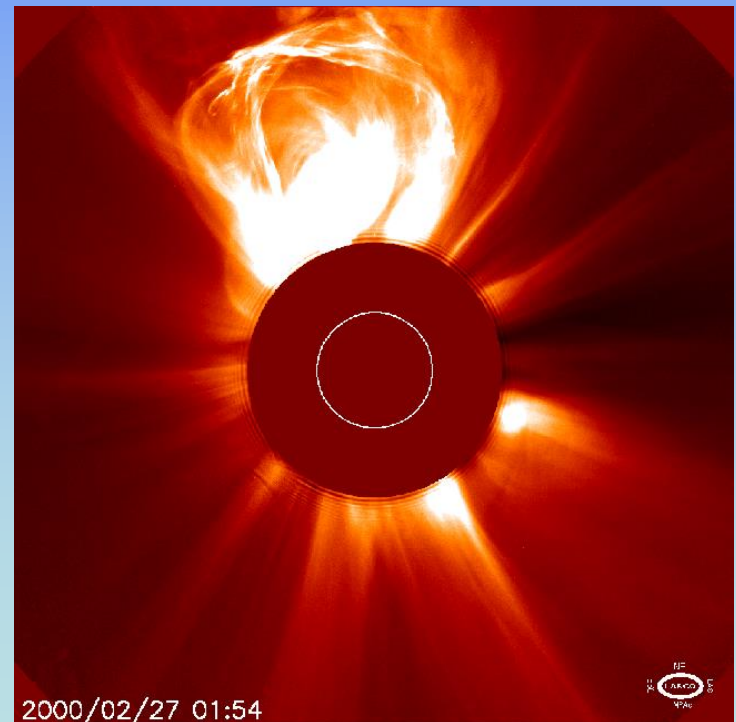
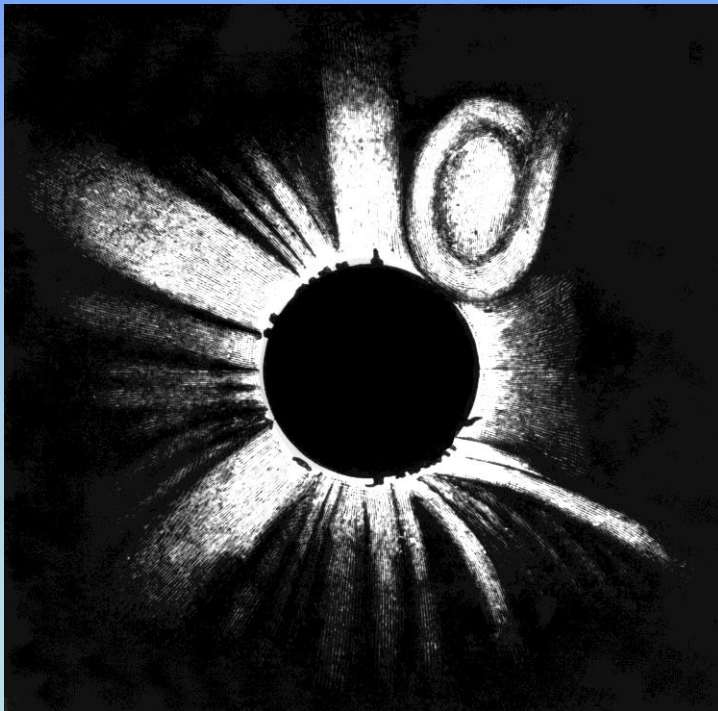
Milestones in the solar corona research

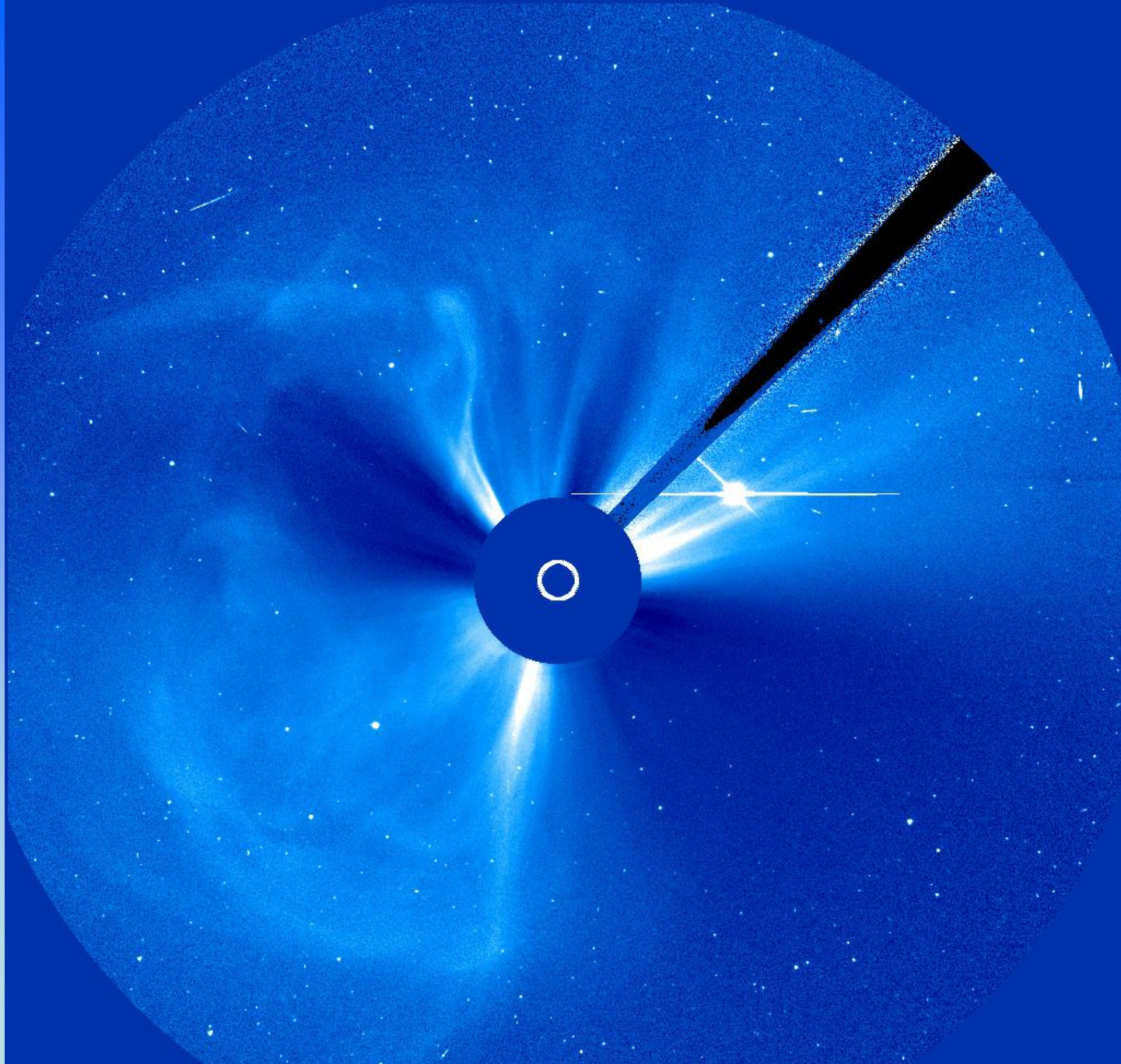
- To 1860 – since Kepler age (1605 eclipse) a faint blue light around the Moon was supposed to be a glory of the Moon or other illumination
- **July 18, 1860 – Angelo Sechci and Warren de la Rue from independent photographic observations in Spain (in distance of about 400 km) stated ‘...the red and white light belongs to the Sun’; observation was supported by the Pope. This conclusion was fully accepted to the end of 19th century.**



First observation of the CME

- July 18, 1860 – discovery of the CME; Tempel at others (confirmed in 1971 by OSO 7 – Dec. 14, 1971, followed with Skylab missions); today, daily observed, if occur

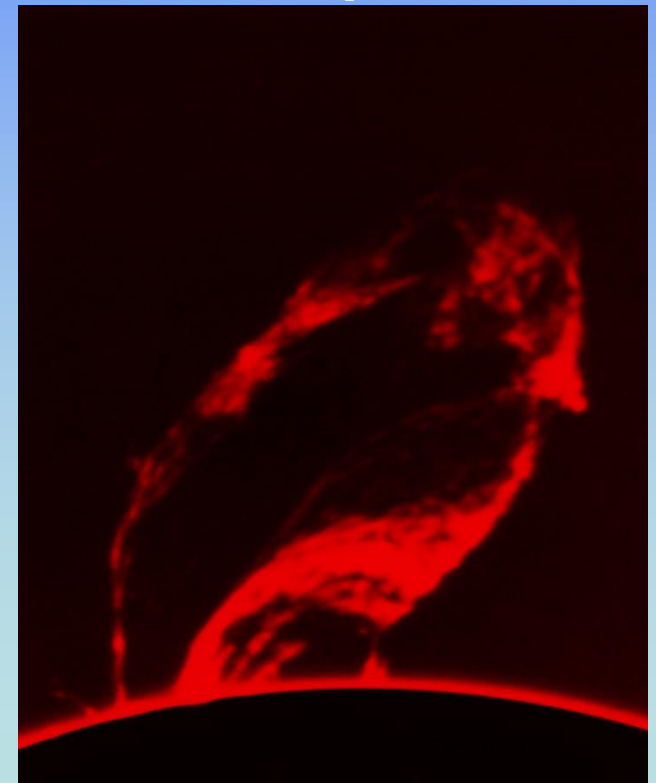
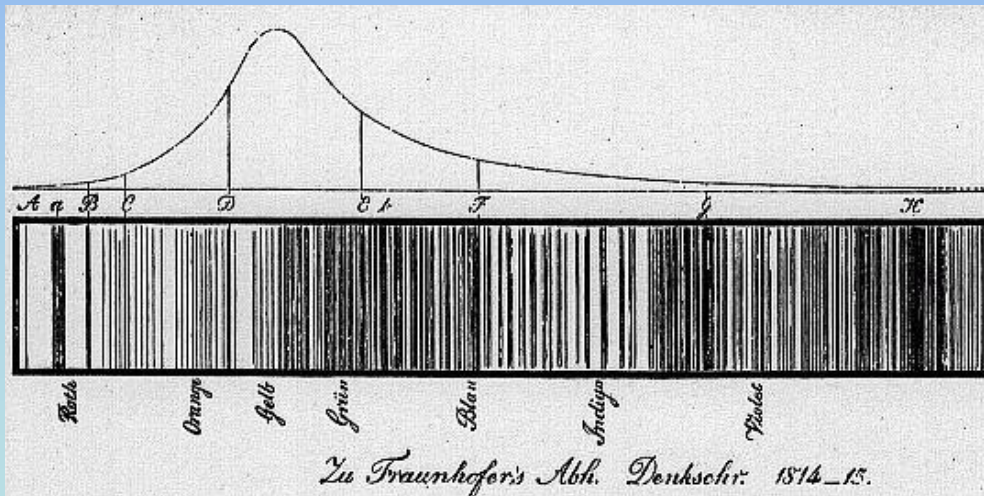




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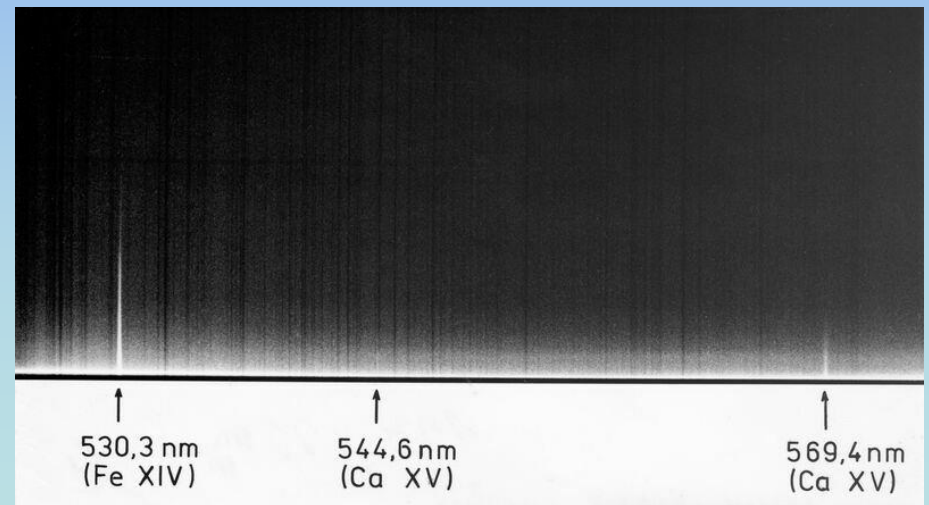
Milestones in the solar corona research

- August 18, 1868 (India) – J. Janssen – discovery of a new chemical element on the Sun – Helium; beginning of prominence observations out of the eclipse; N. Lockyer did the same out the eclipse



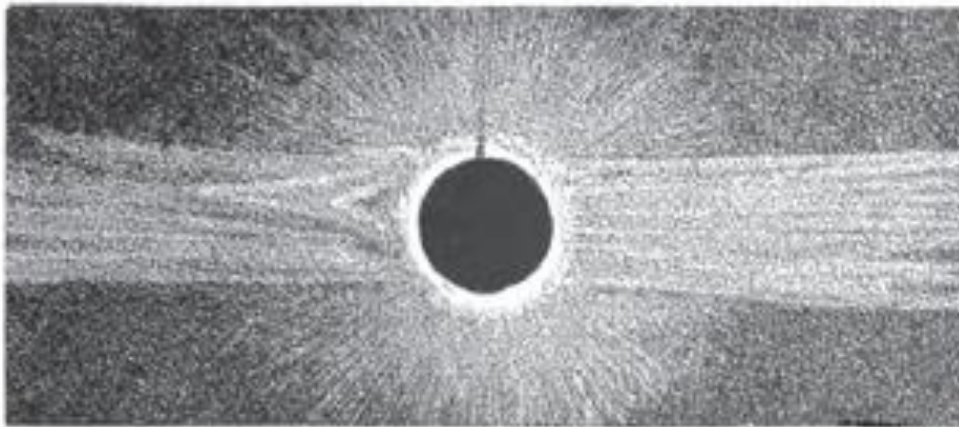
Milestones in the solar corona research

- 1869, august 7– Ch. Young; discovery of a new emission line in the corona – 530.3 nm; a new chemical element on the Sun; ‘coronium’ ? No, but its puzzle, similar as other emission coronal lines lasted to the 40th in the 20th century. Solution was given by W. Grotrian and B. Edlen - in 1941. ***The solar corona happened very hot – more as 10E6!***



Milestones in the solar corona research

- July 29, 1878: S. P. Langley, C. Abbe and S. Newcomb - observation of the long ray up to 6° in the ecliptic plane; they proposed that a source of this light is a zodiacal light, and also, a composition of this long ray can not be from a firm material.

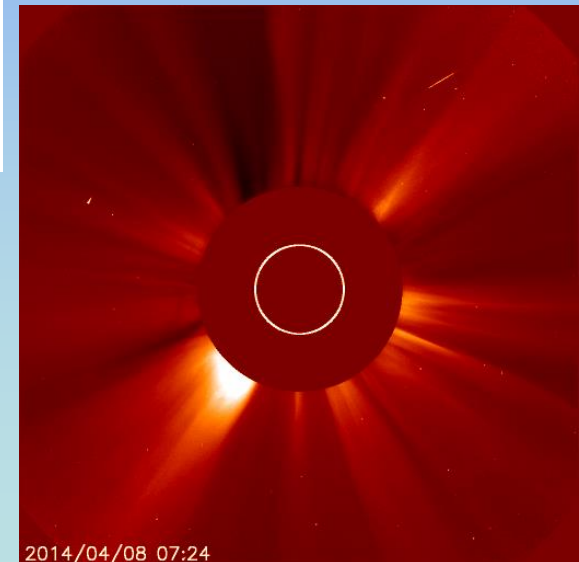
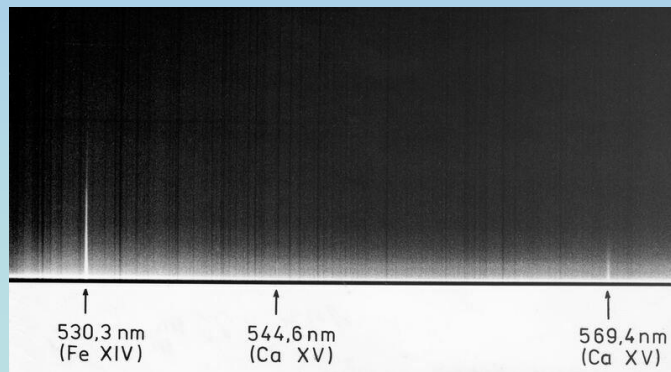
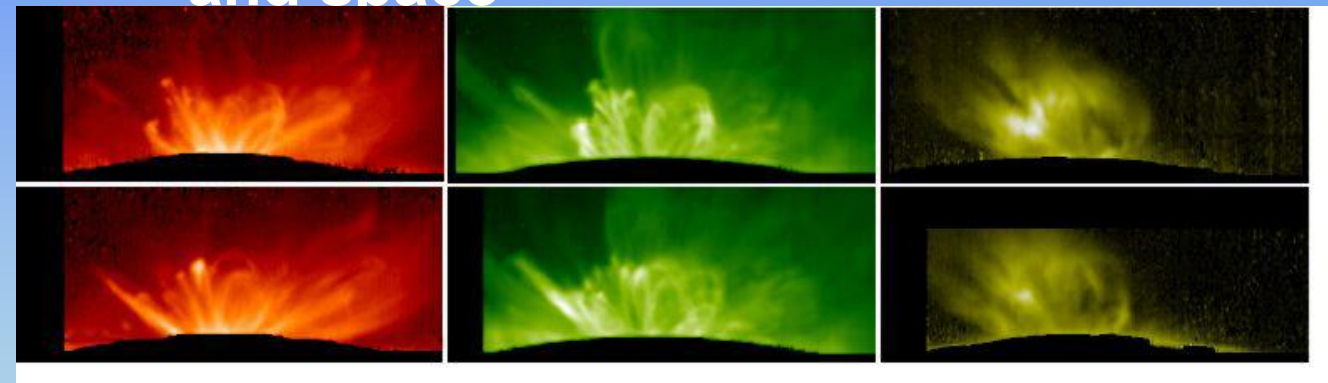


THE CORONAL STREAMERS OF 1878 (LANGLEY)



Milestones in the solar corona research

- 1931 - B. Lyot designed a new instrument – coronagraph; with a different post-focal equipments is using to observe the solar corona from ground and space



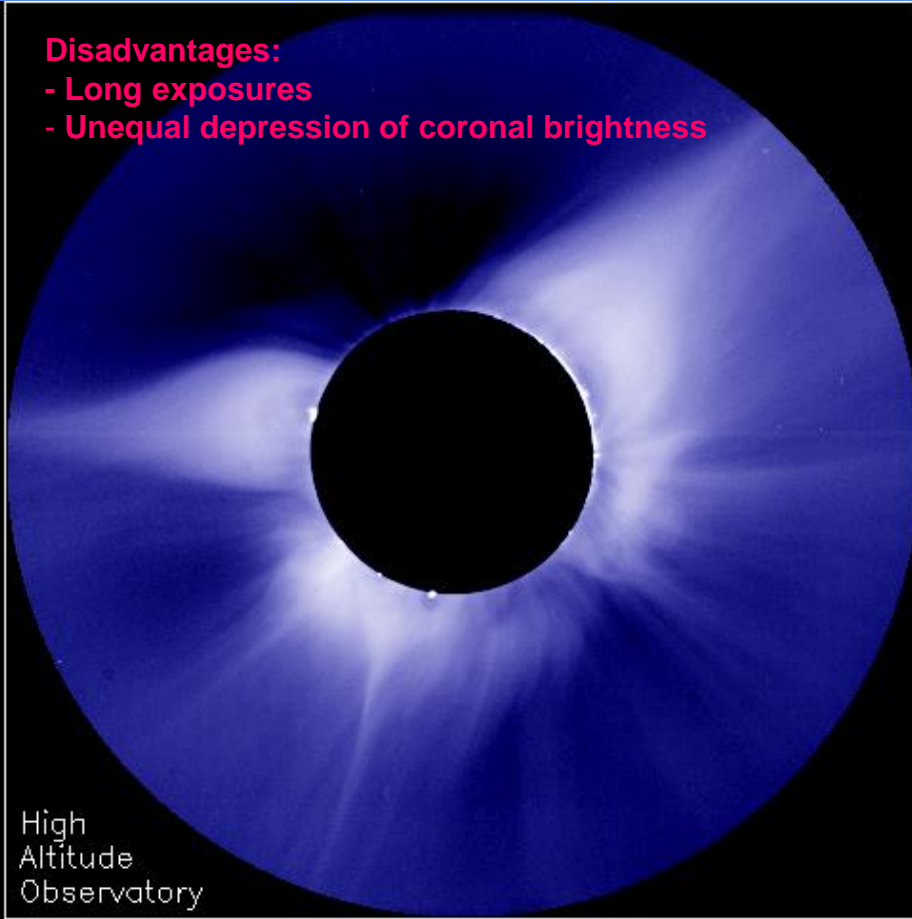
Milestones in the solar corona research

- 1948 - Separation of the white-light corona into K- and F-components (based on spectral analysis)
- 1961 – using a rotating sector near the telescope focus (Laffineuer, 1961) to suppress very bright inner corona brightness and to show faint structures of the outer corona
- 1966 – discovery of the thermal emission from interplanetary dust at 2.2 μm around 4 solar radii (Peterson, 1967) – T- corona ?
- **1966 – a using of radial graded filter proposed by Newkirk (the Newkirk White Light Coronal Camera)**
- **Xxxx – Sabattier effect (used in a darkroom)**
- **1988 – S. Koutchmy – Mad MAX2 – digital image processing to improve coronal imaging; and many authors at present**

1996 and 1973 eclipses

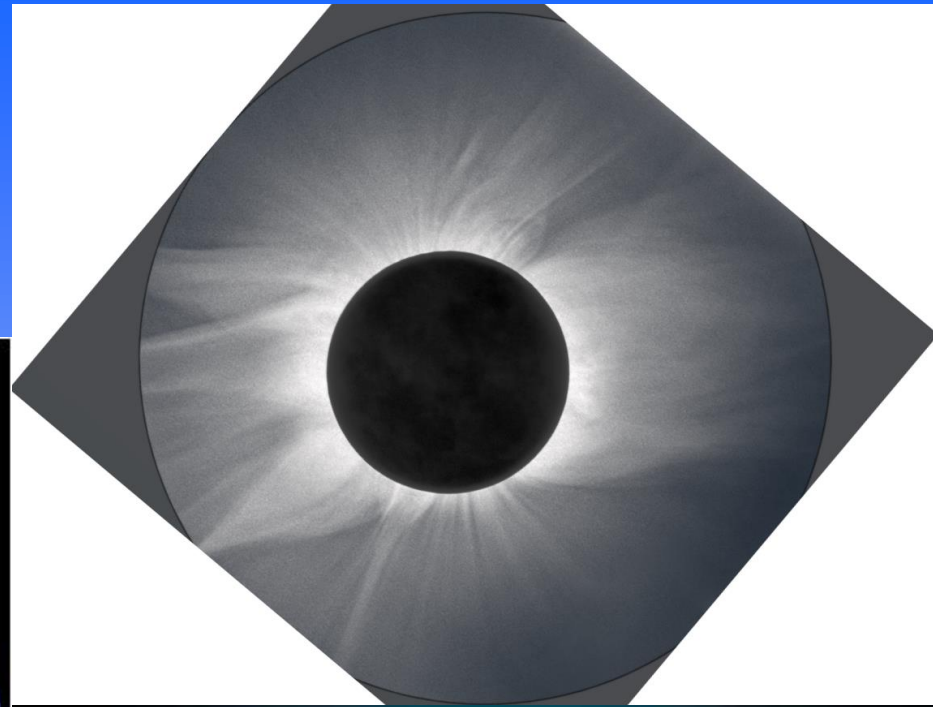
Disadvantages:

- Long exposures
- Unequal depression of coronal brightness



High
Altitude
Observatory

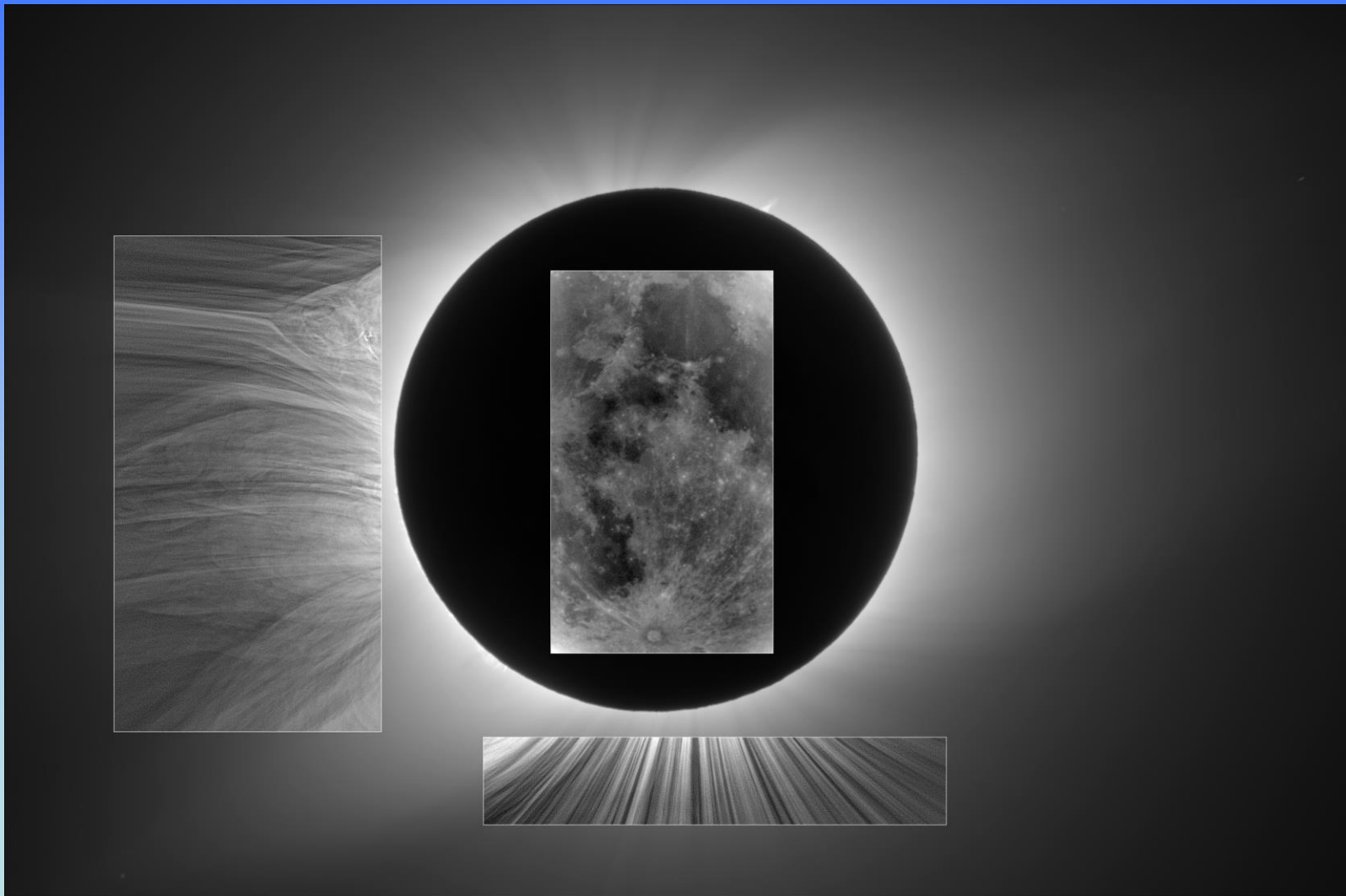
12 November 1988 – Total Solar Eclipse – Pulacayo, Bolivia



Milestones in the solar corona research

- **1991 - S. Koutchmy and others – observation of the WLC with 3.9 m telescope on Hawaii – discovery of super faint structures-plasmoids - in the WL corona (0.5 arcsec or less)**
- **1999 – R. Gulyaev – proposal for a sublimation corona (S-corona); evaporation of dust particles around 4-10 solar radii; detection in spectral lines around HaK (393.37 nm)**
- **2005 – Druckmuller et al. published one of the best image processed method for the solar corona**
- **2008 – simultaneous observations in the green corona (530.3 nm) and its surrounding**
- **2010 – Habbal et al., - multi observations of the solar corona using 6 different narrow pass-band filters and their surrounding simultaneously + H-alpha and WLC**

Milestones in the solar corona research – Druckmuller's method



Present status of the solar corona



Total Solar Eclipse 2010

© 2010 Miloslav Druckmüller, Martin Dietzel, Shadia Habbal, Vojtech Rušin

Present status of the solar corona

- **WLC is highly structured**
- **WLC is highly different in the temperature and densities**

Present status of the solar corona - components

- **The solar corona consists of three different components:**
- **K- corona (Thompson scattering on free electrons), polarized**
- **F- corona (scattering of photospheric lights on dust particles), unpolarized**
- **E- corona (proper light from highly ionised species, e.g. Fe, Ca, Ni, Ar, etc.)**

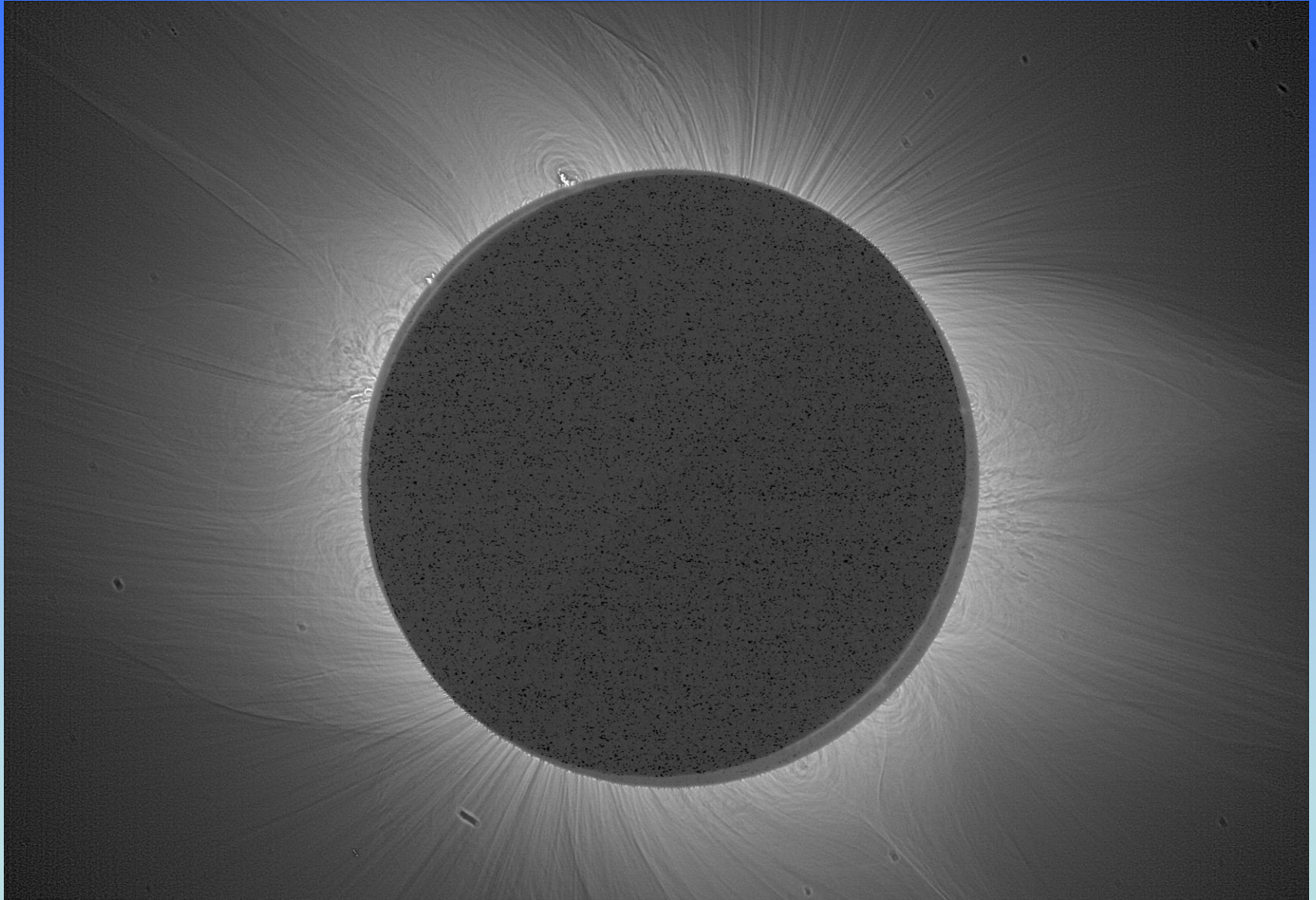
Some examples-T and structures



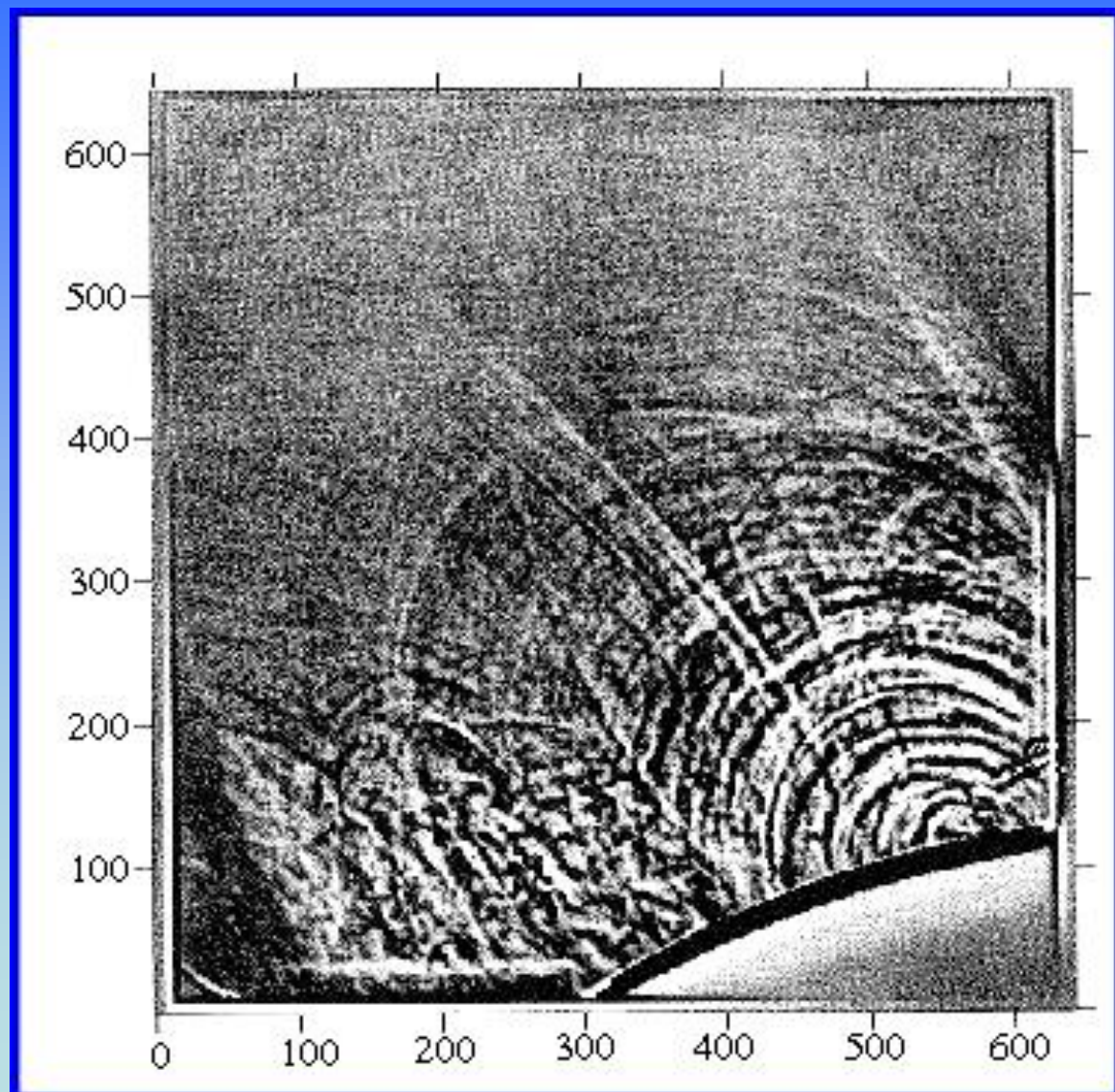
Total Solar Eclipse 2010

White light / Fe X 637.4 nm red / Fe XIV 530.3 nm green

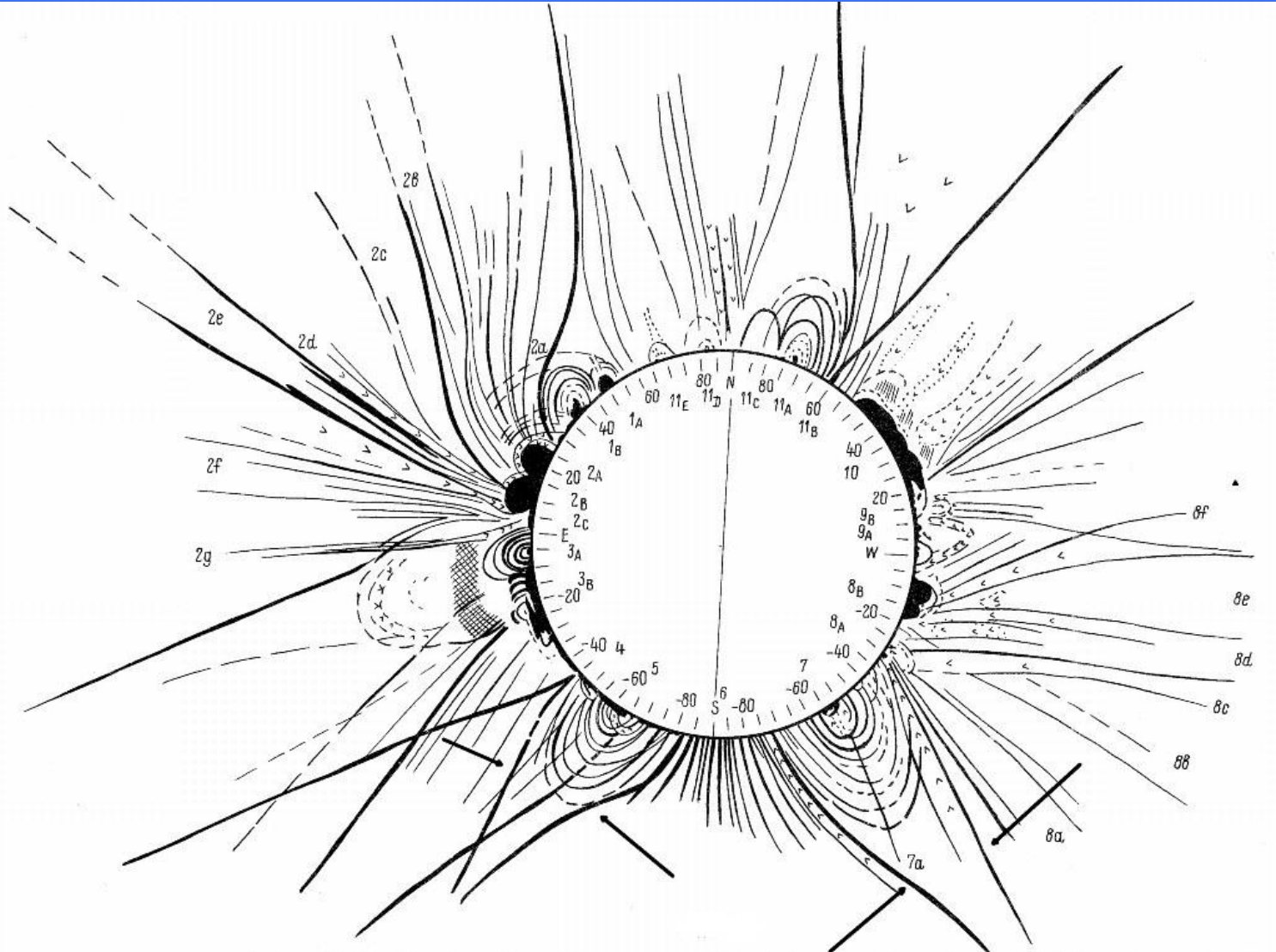
Some examples-structure



Some examples-structure

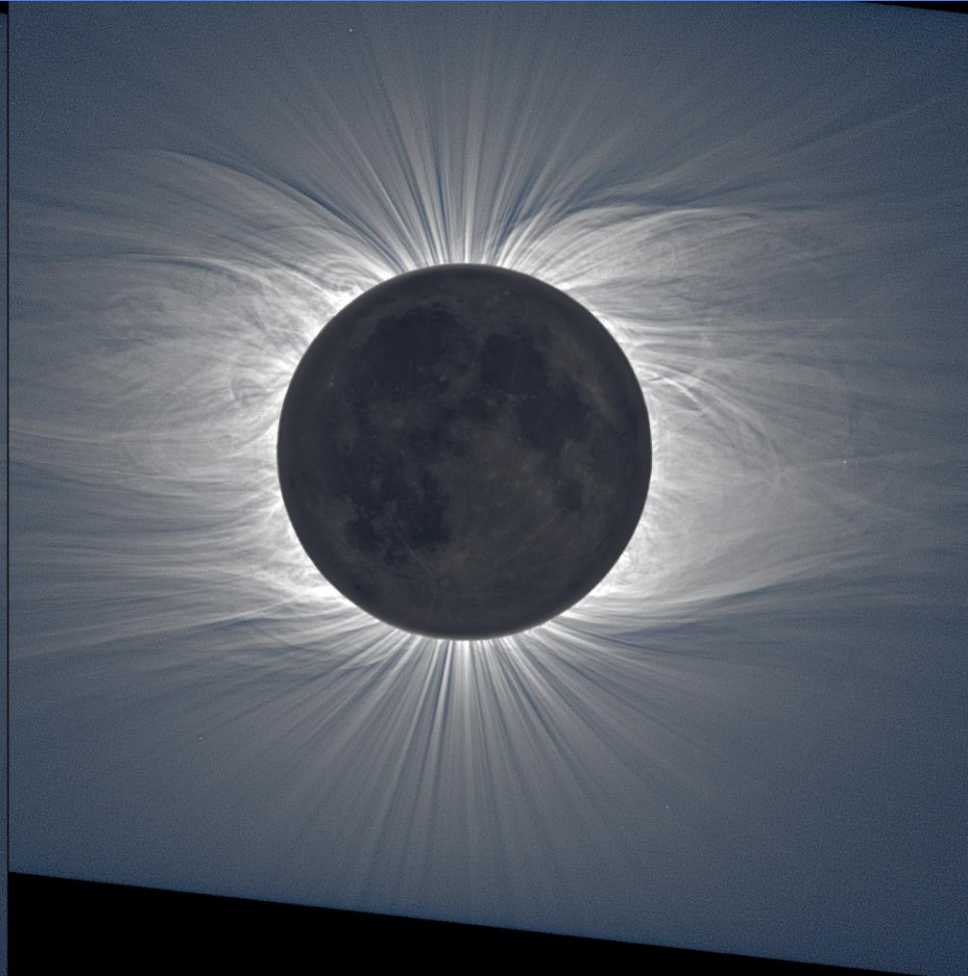
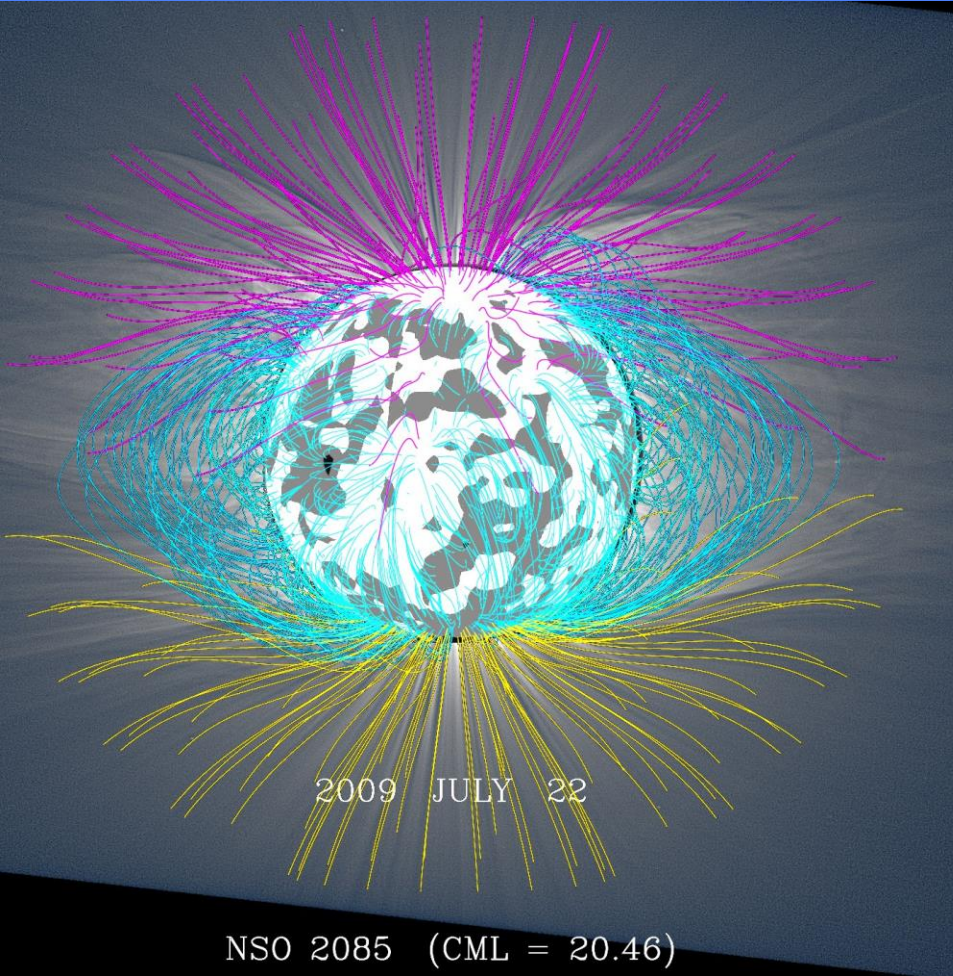


Some examples-structure

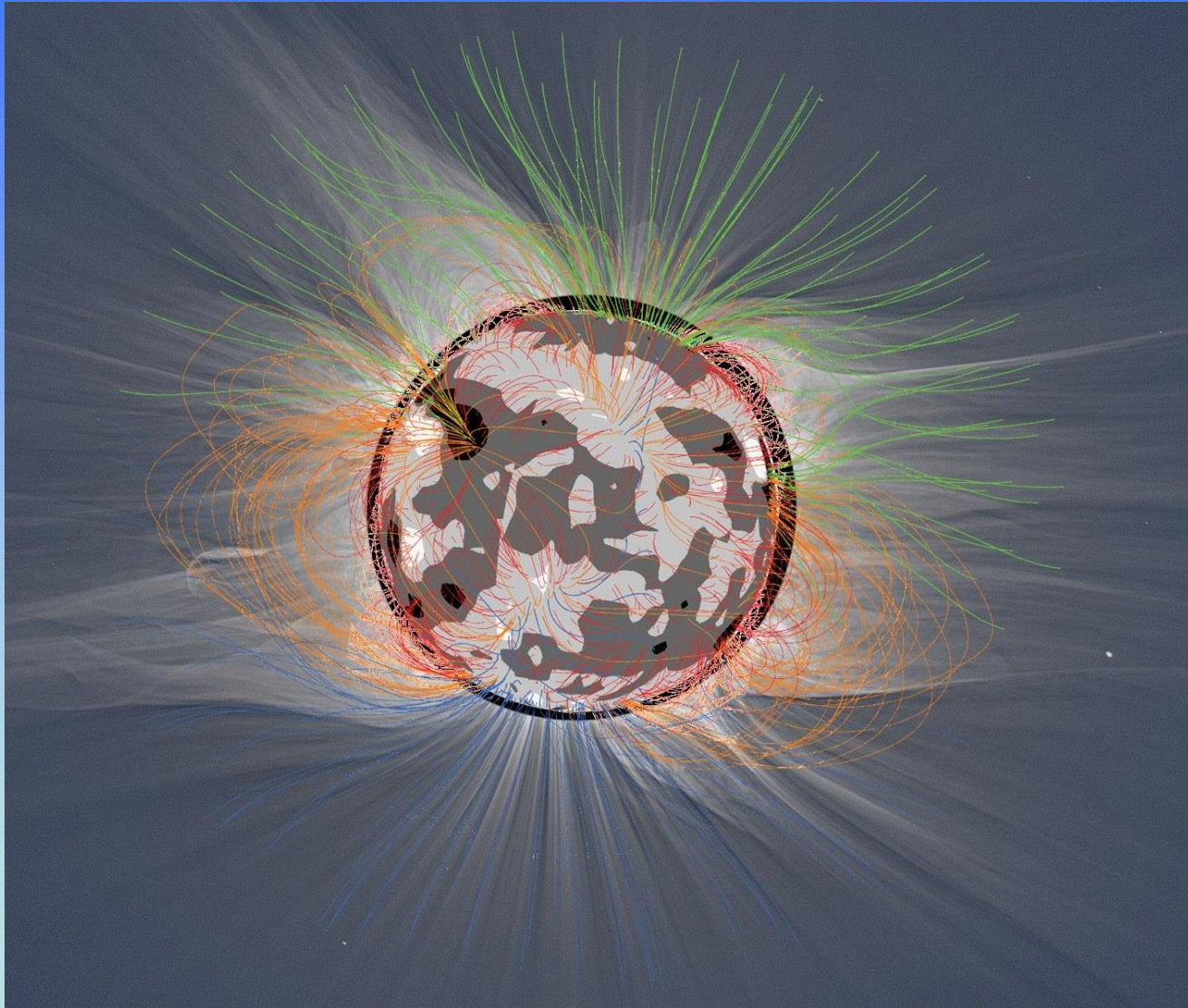


The 1968, September 22 corona (Vsekhsvjatsky et al., 1970)

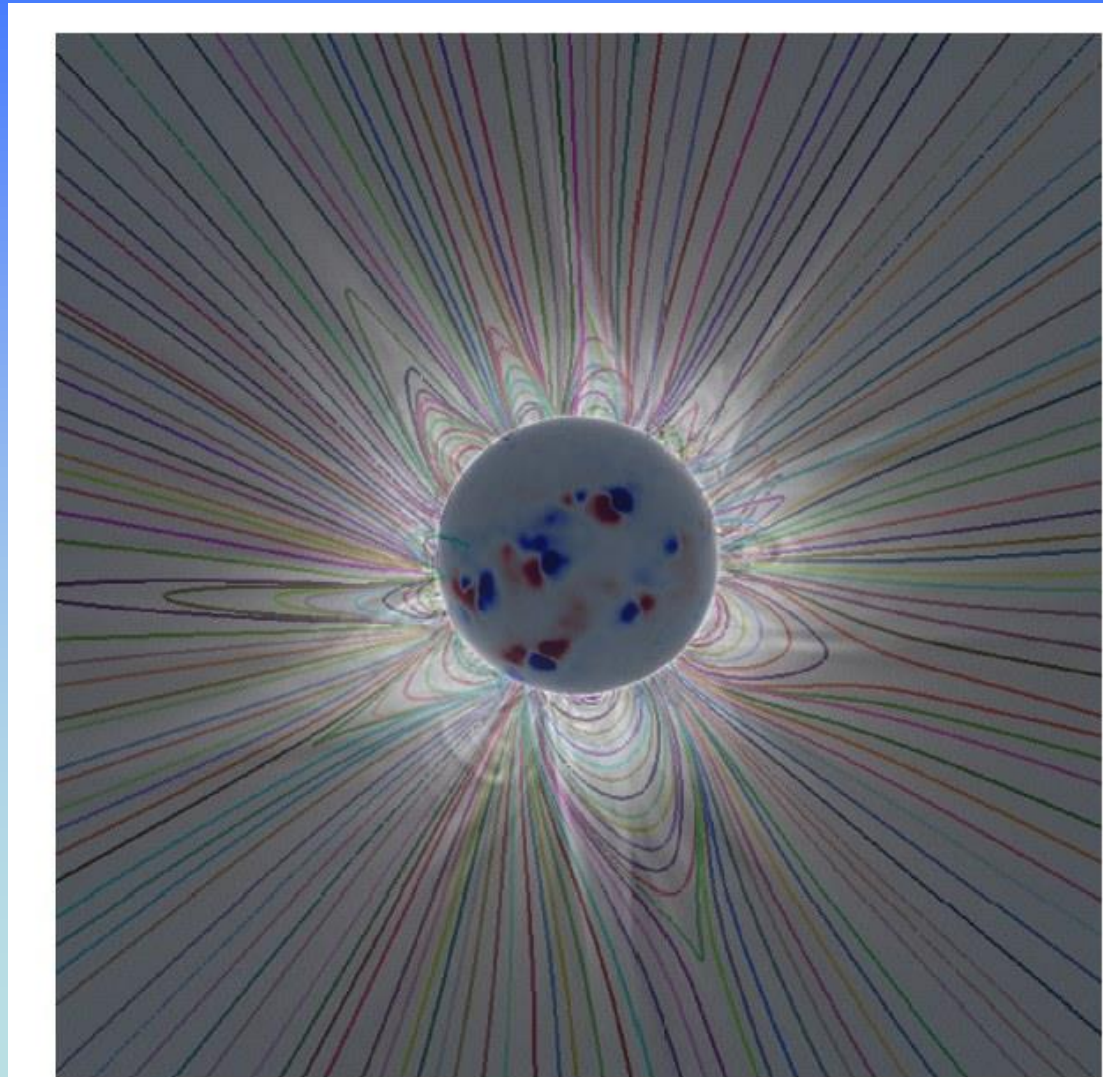
Some examples-magnetic fields - 2009



Some examples-magnetic fields - 2010



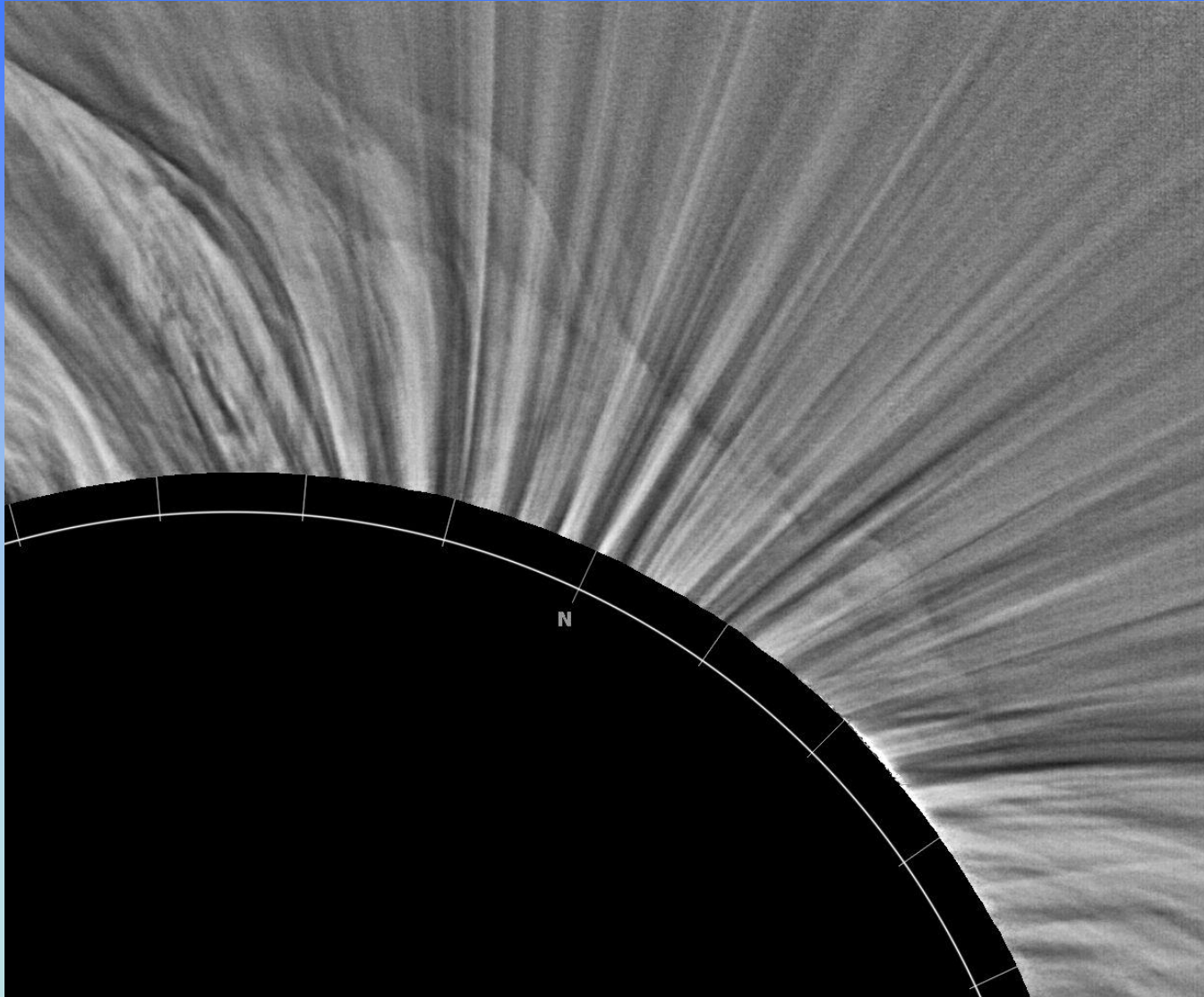
Some examples-magnetic fields - 2012



Present status of the solar corona - features

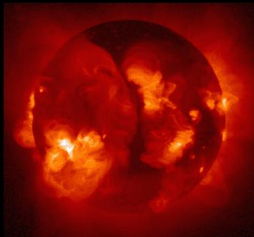
- Large-scale: helmet streamers, coronal holes (discovered from space, but also observed during eclipses), polar plumes, coronal mass ejections
- Small-scale: coronal cavities, loops, condensations, threadlike structures (helmet streamers observed on-edge?), magnetic arcades, voids, 'curtains?'
- Corona is highly structured with different features, created and maintained by magnetic fields in the solar corona
- Individual structures are always connected with solar surface magnetic fields

WLC – ‘curtain’

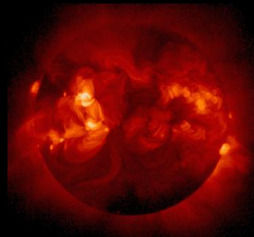


Present status of the solar corona – slow dynamics

28.9.1991



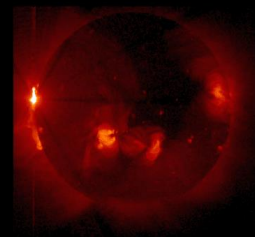
27.3.1992



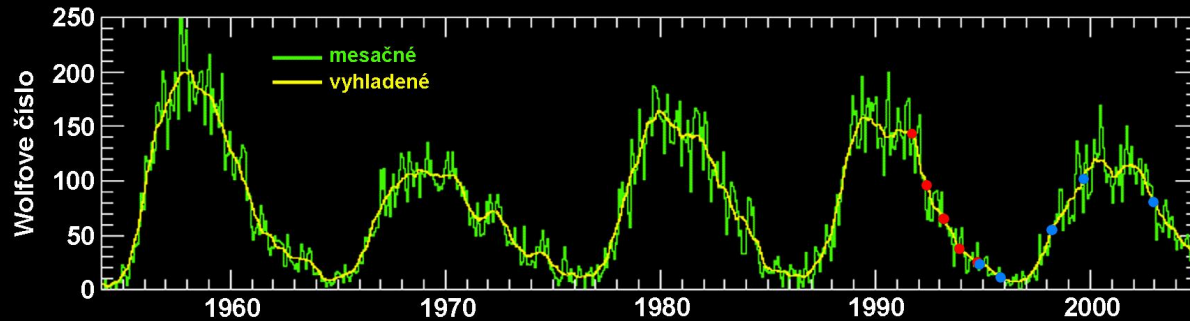
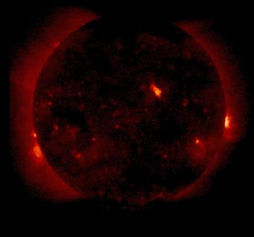
26.1.1993



4.11.1993



20.9.1994



3.11.1994



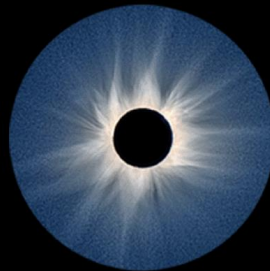
24.10.1995



26.2.1998



11.8.1999

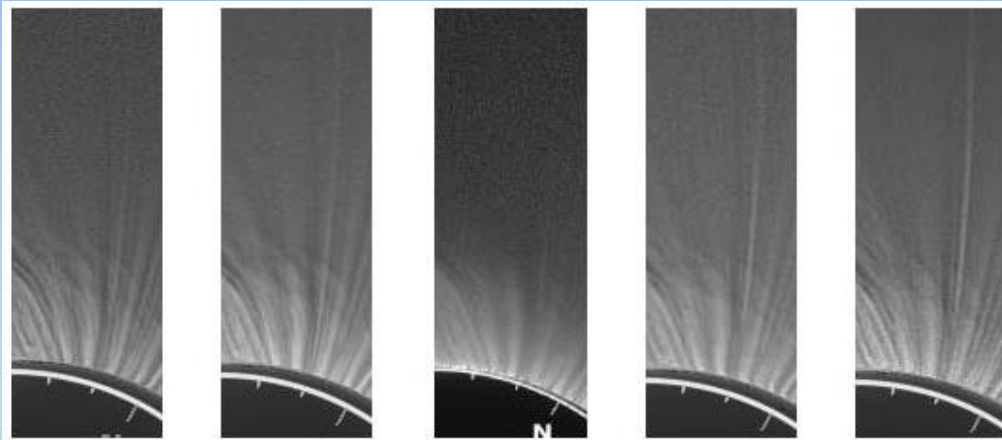


4.12.2002

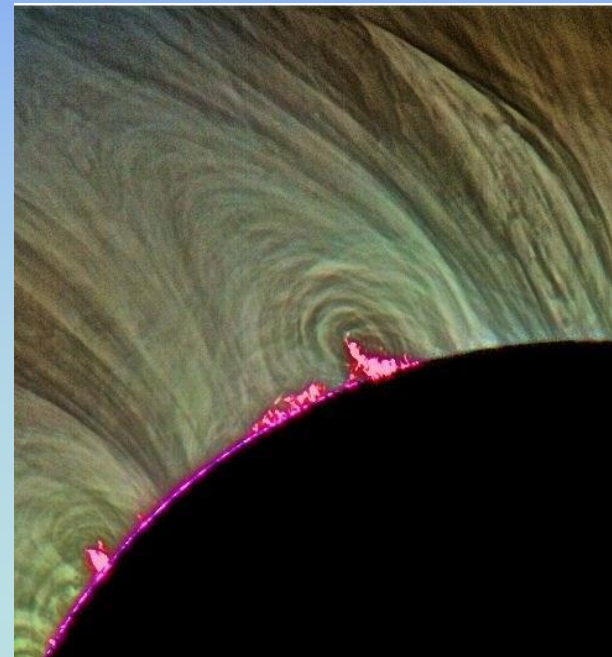


Present status of the solar corona - dynamics

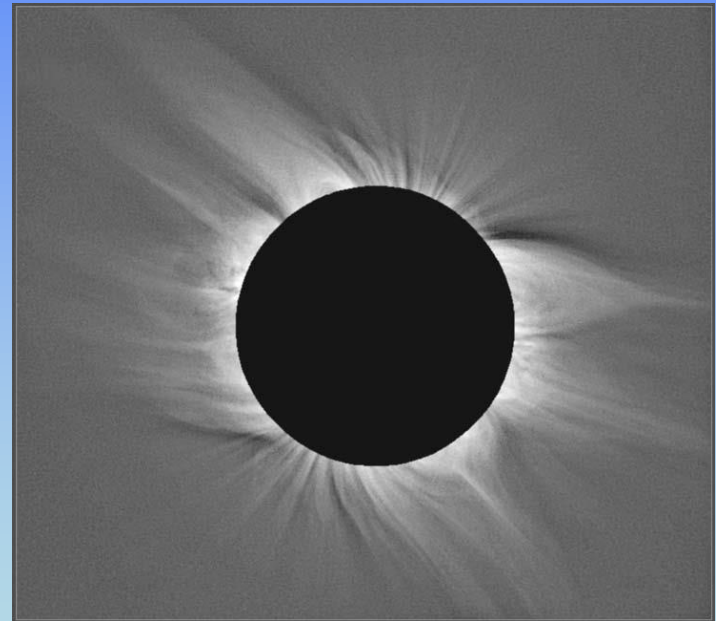
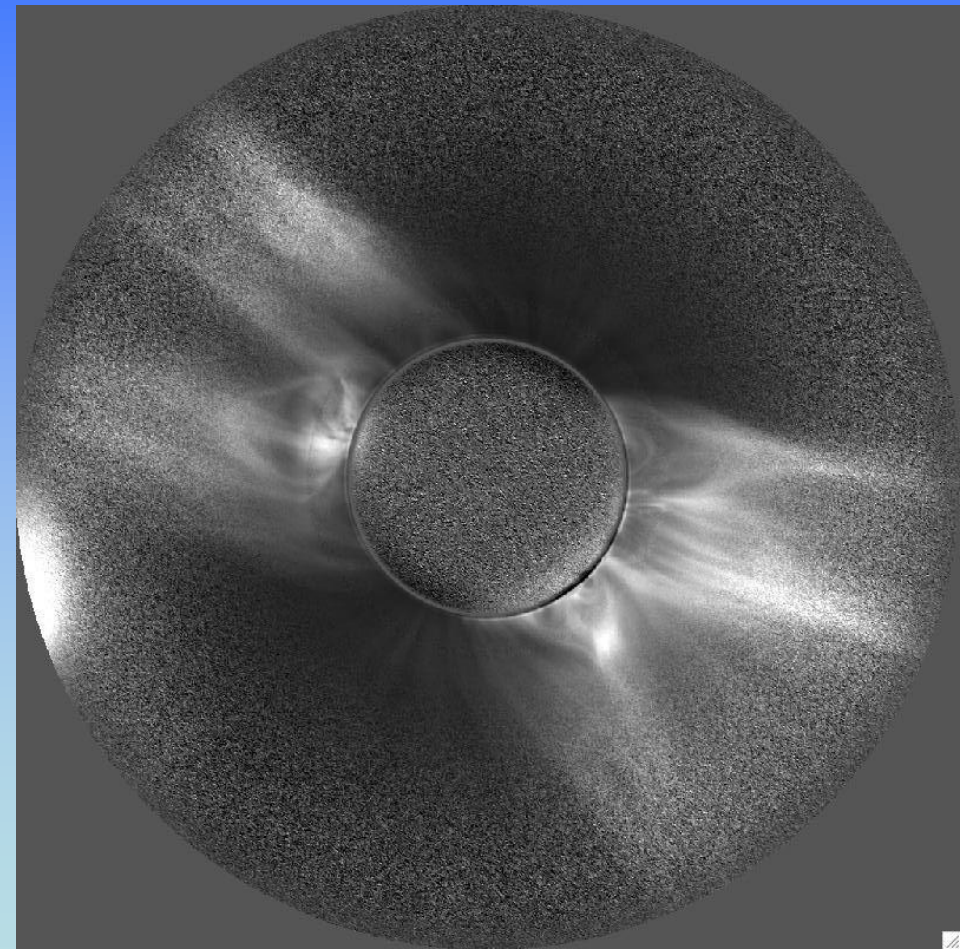
- Development and time-latitude shift of helmet streamers (similarly as prominences and magnetic fields on the solar surface)
- Dynamics of polar plumes (lifetime)
- Connection between prominences and coronal structures? Probably yes.



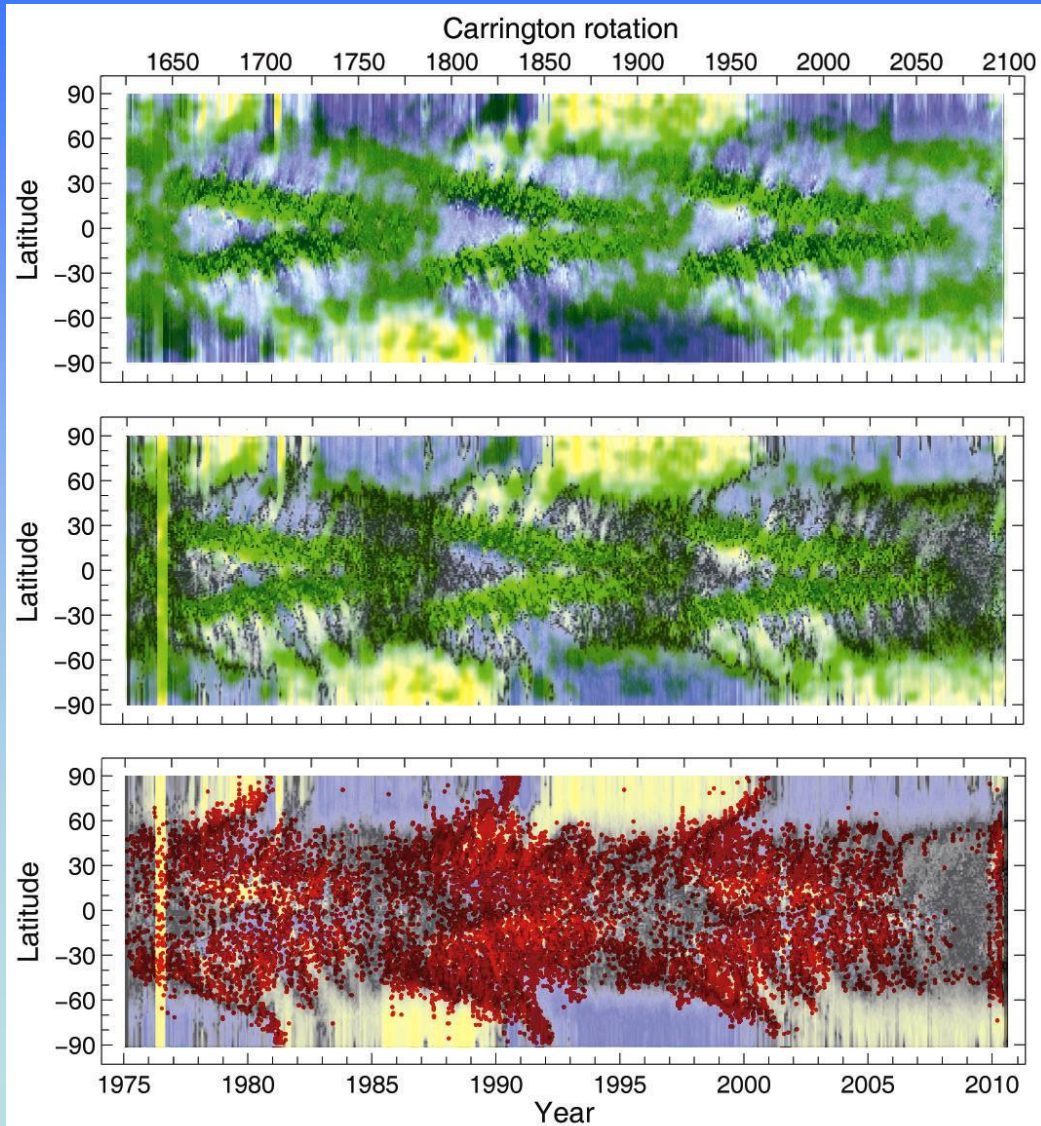
$V = \text{around } 65 \text{ km/s}$



789.2 nm and WLC in 2006

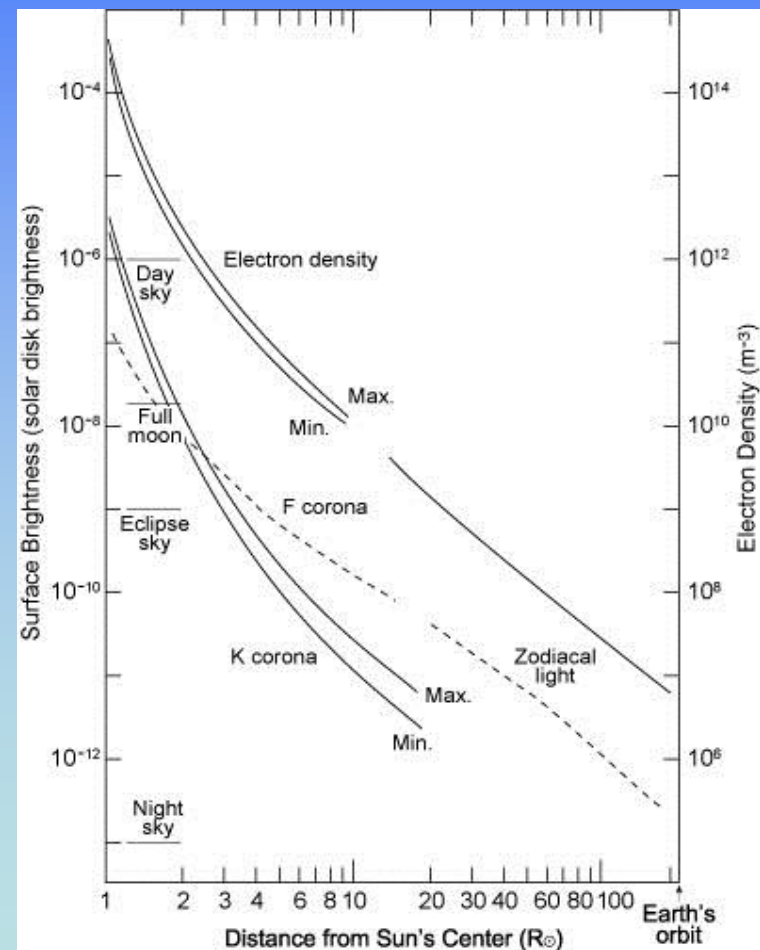
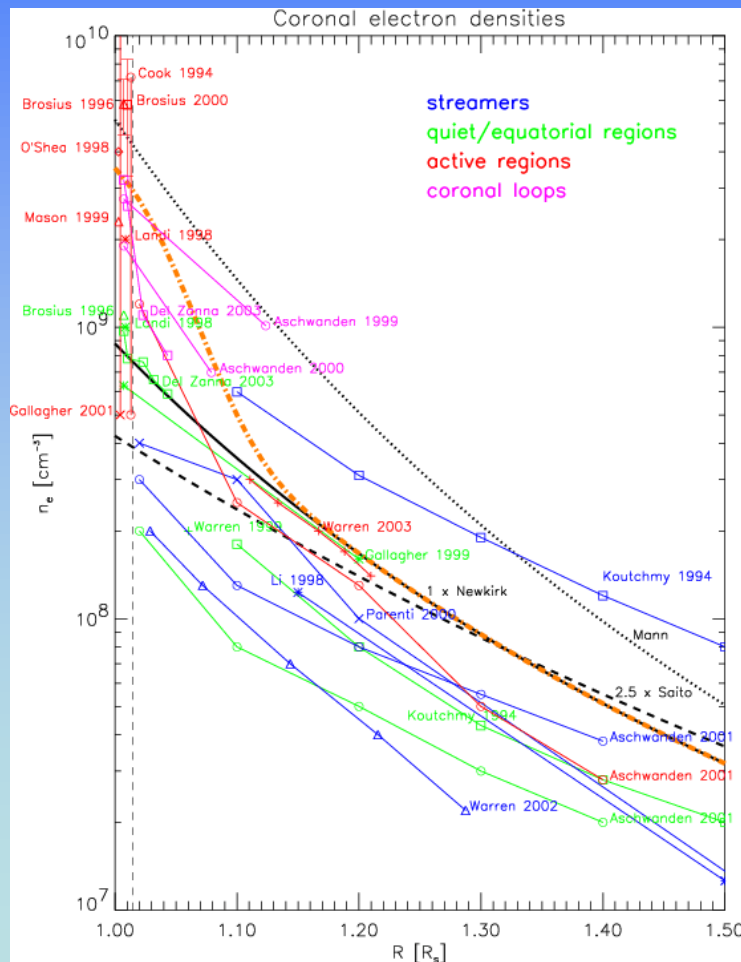


Time-latitude shift: green corona, prominences and magfields



Present status of the solar corona – physical properties

- Brightness of the WL corona depends of its density



What in the future?

- **S. Koutchmy in the 1987 at Sacramento Peak meeting said: “Optical observations, which could give us the best spatial resolution, are still of “amateur-size” apertures”.**
- **Still valid, even when some progress has been done: spatial and temporal resolution are needed with a high quality and speed, using CCD cameras!**
- **Heating mechanism for the hot corona and a matter supply to the corona from solar surface – permanent questions for all solar physicians; I will not deal to these question.**
- **Let’s try to do with eclipse observation of the solar corona:**
- **Width of helmet streamers at their base**
- **Lifetime of polar plumes and their connection to solar surface regions**
- **Dynamics of polar plumes**
- **Are polar plumes in the WLC identical with EUV polar rays?**

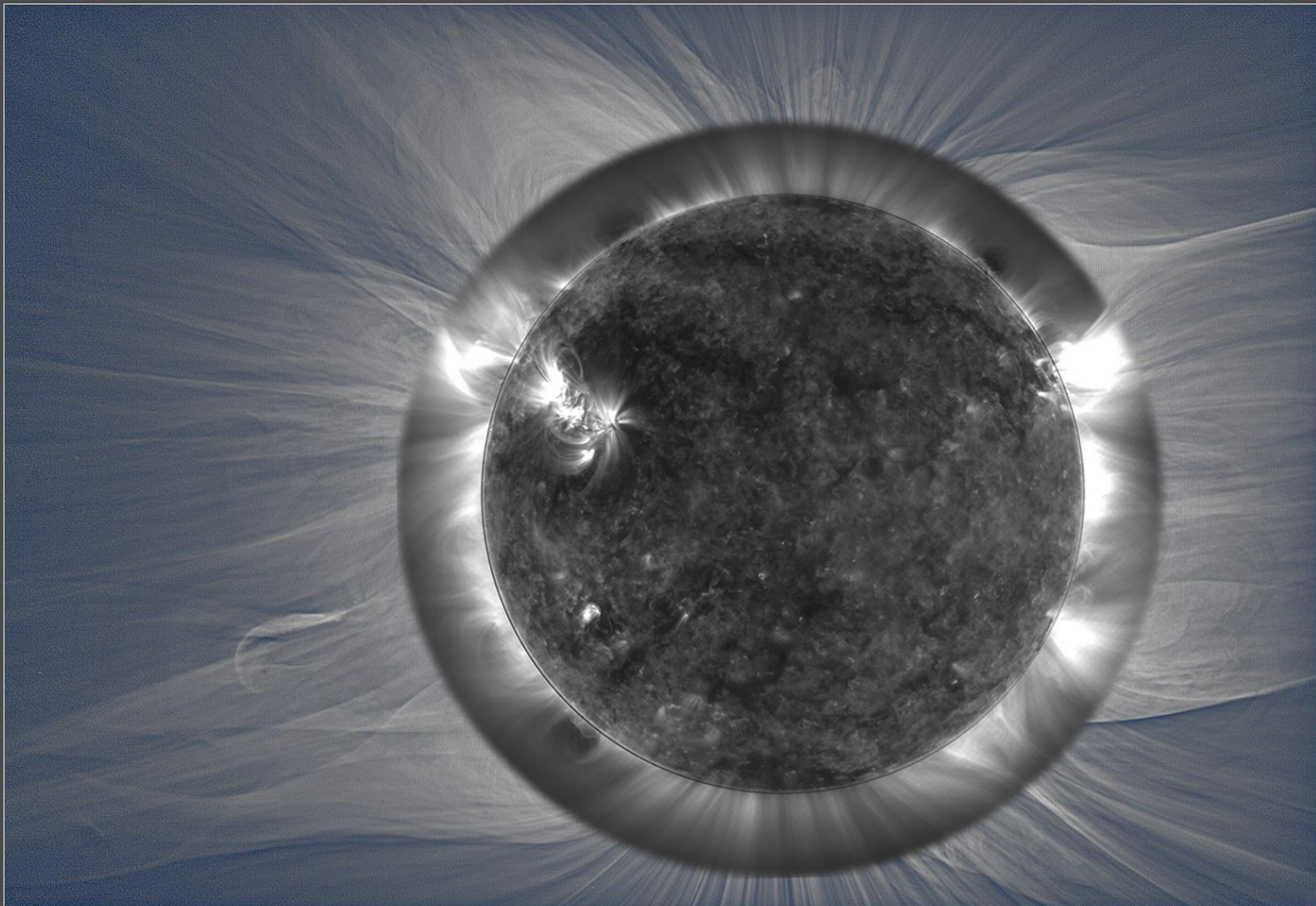
What in the future?

- **Polarization of the WL and emission corona (The highest magnetic sensitivity of spectral lines: 530.3 nm, 1074.7 nm and 3934 nm.)**
- **Helmet streamers and magnetic field connection**
- **Multicolor pictures of the corona in different emission lines, e.g. in Fe ions, Ca ions, etc.**
- **Connection between cool prominences and hot corona. Why? What components? H or electrons?**
- **Why coronal loops in the WL corona out of active regions do not show similar structures in emission coronal lines, e.g. Fe XIV? Is than WL corona cooler?**

What in the future?

- **Observations of emission coronal lines very far in the infrared part of the spectrum: 1431 nm (Si X), 2047 nm (Al IX), 3032 nm (Mg VIII), 3859 nm (Si IX) and 3934 (Si X) – predicted and some of them observed;** (*Penn, M.J., 2014, Infrared Solar Physics, Living Rev. Solar Physics 11*)
- **Measurements in emission lines Fe XIII 1074.7 and Fe XIII 1079.8 are made nearly regularly**

WLC and PROBA2/SWAP corona during the 2010 eclipse

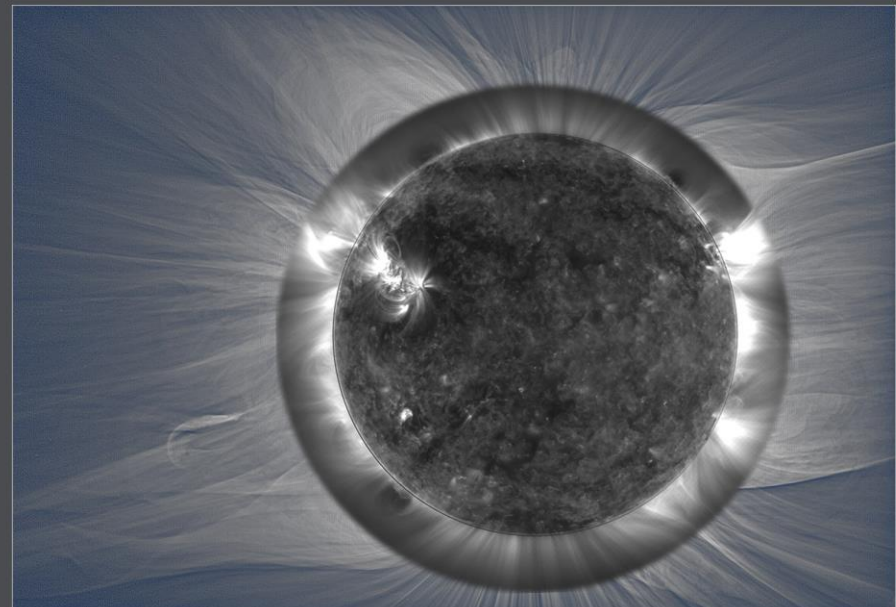


WLC and PROBA2/SWAP corona



Total Solar Eclipse 2010

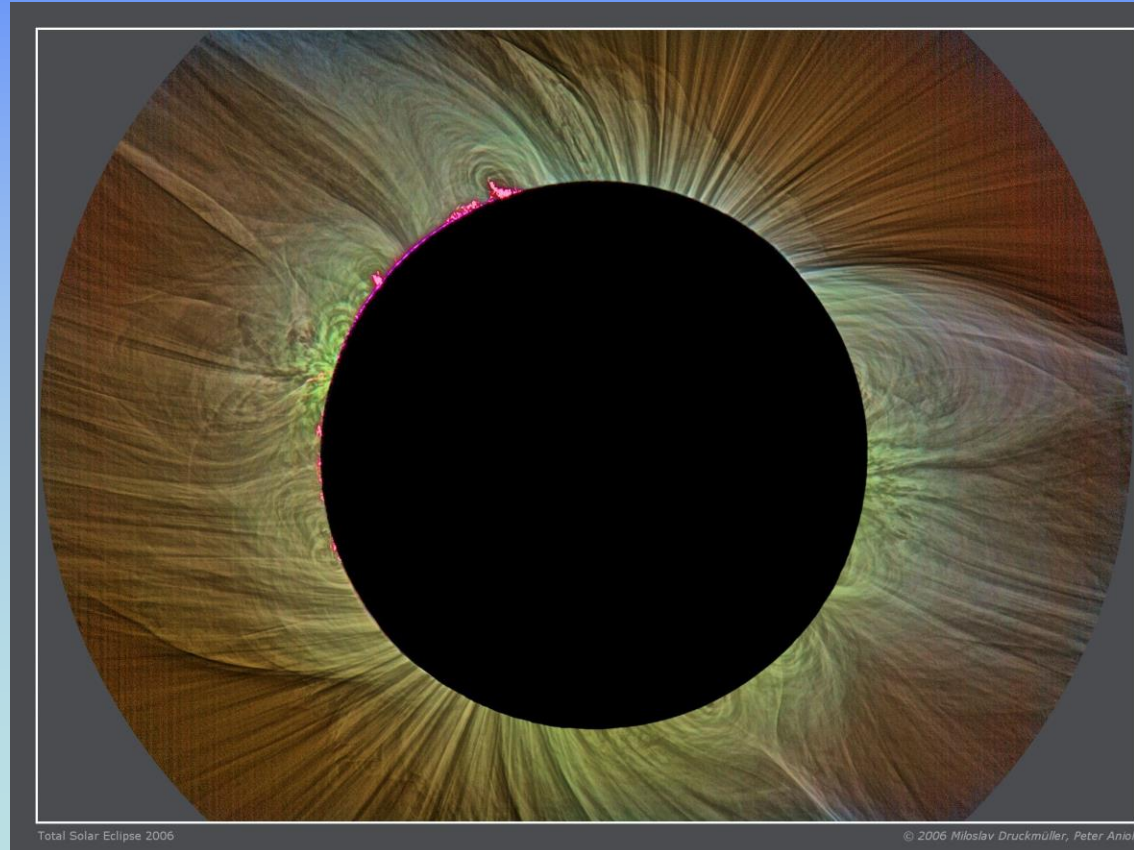
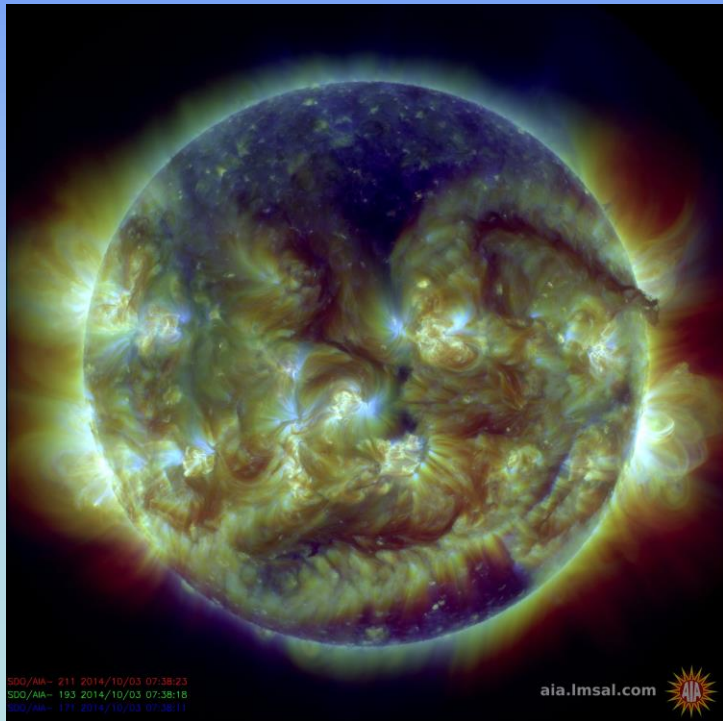
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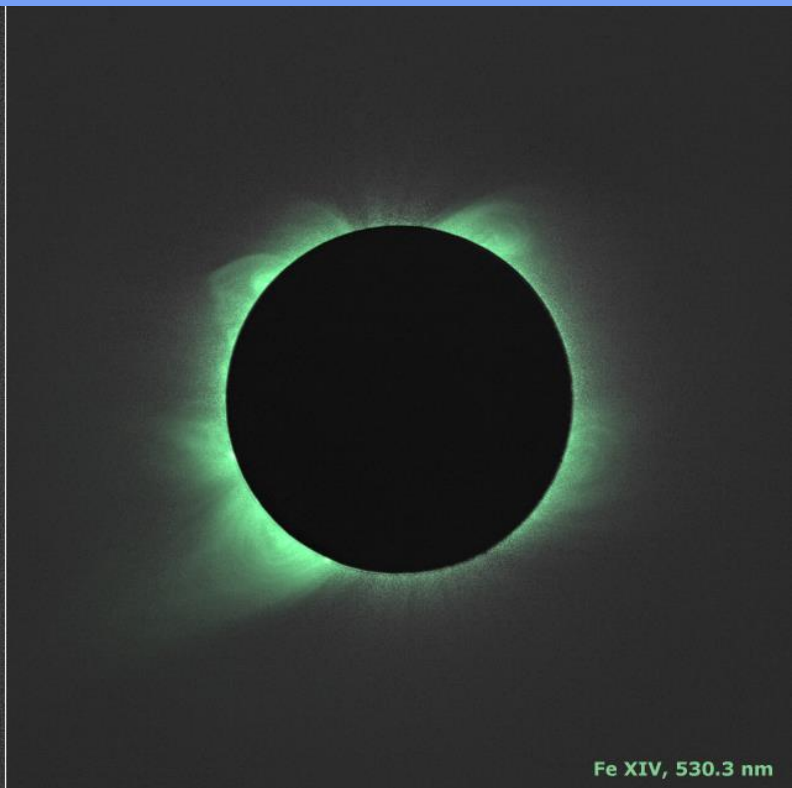
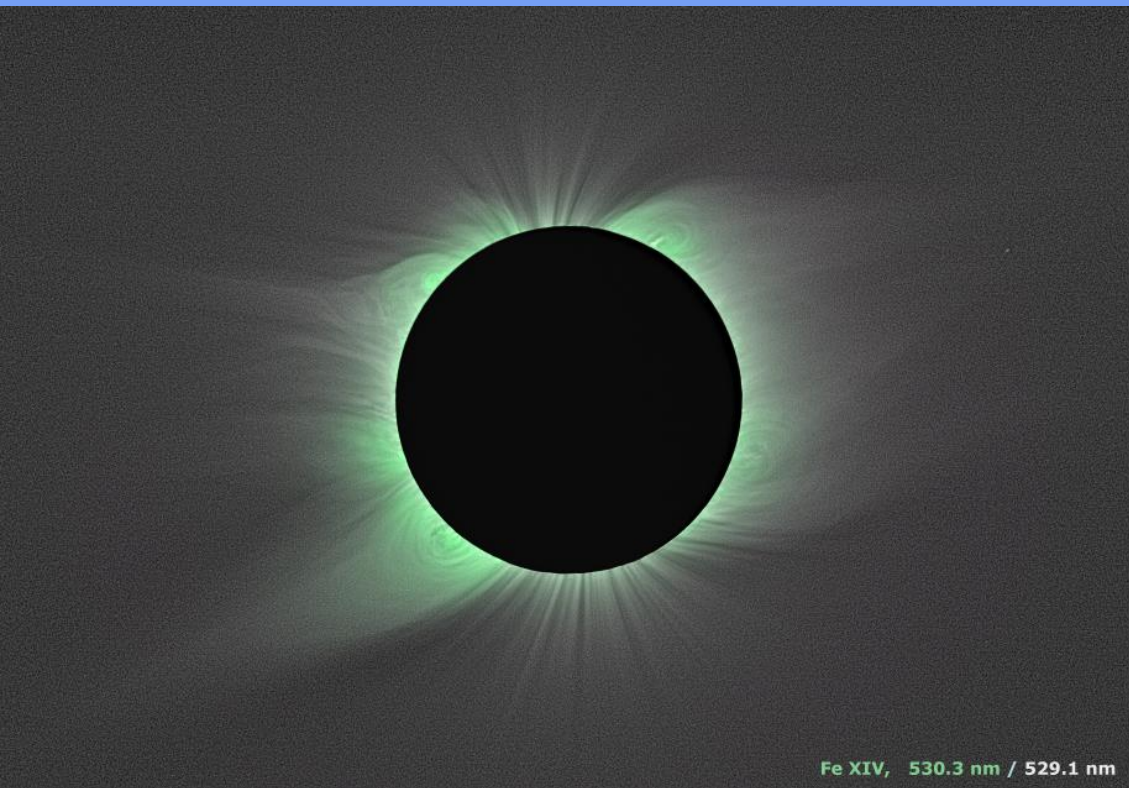


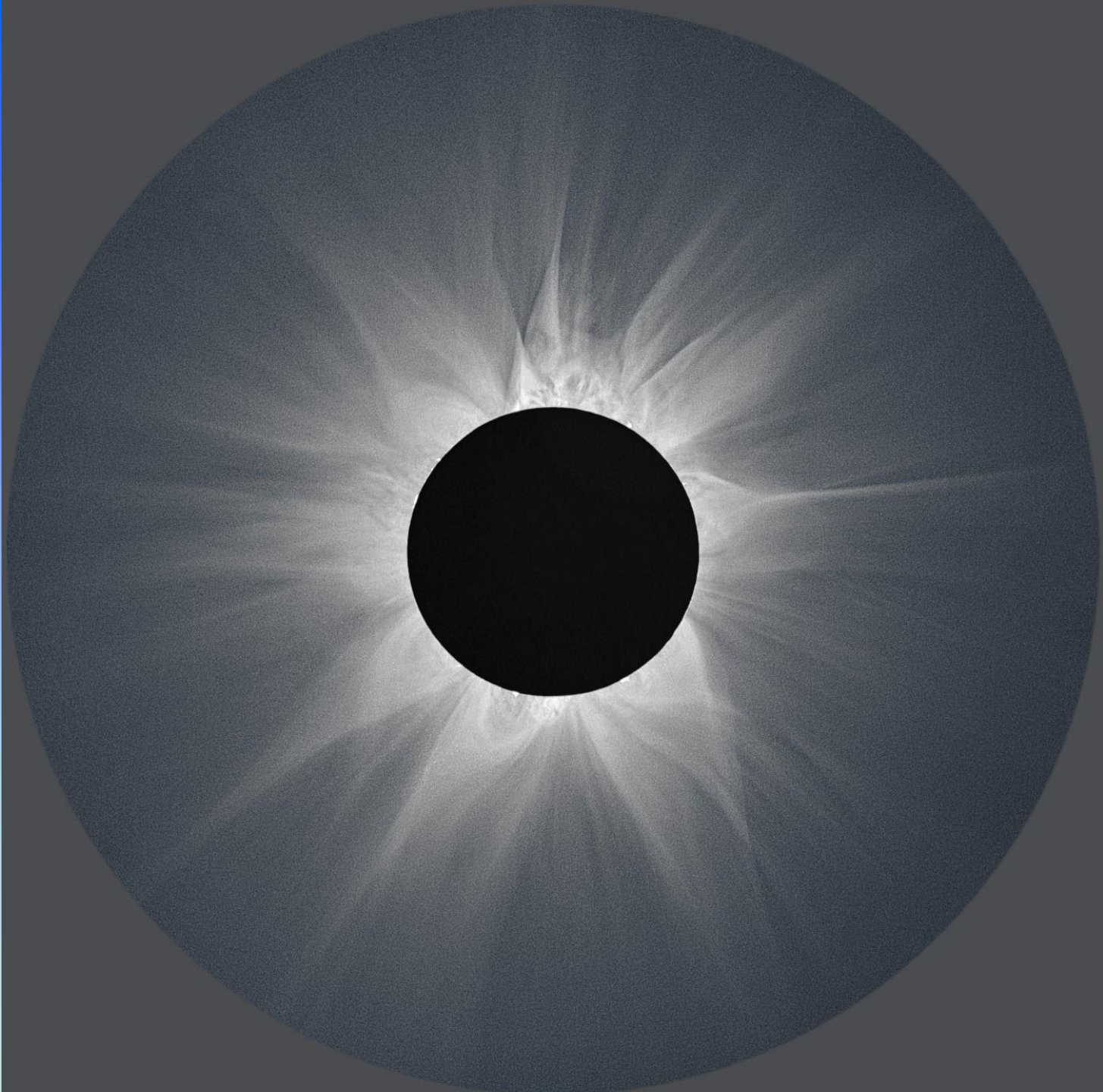
Total Solar Eclipse 2010

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AIA and eclipse corona





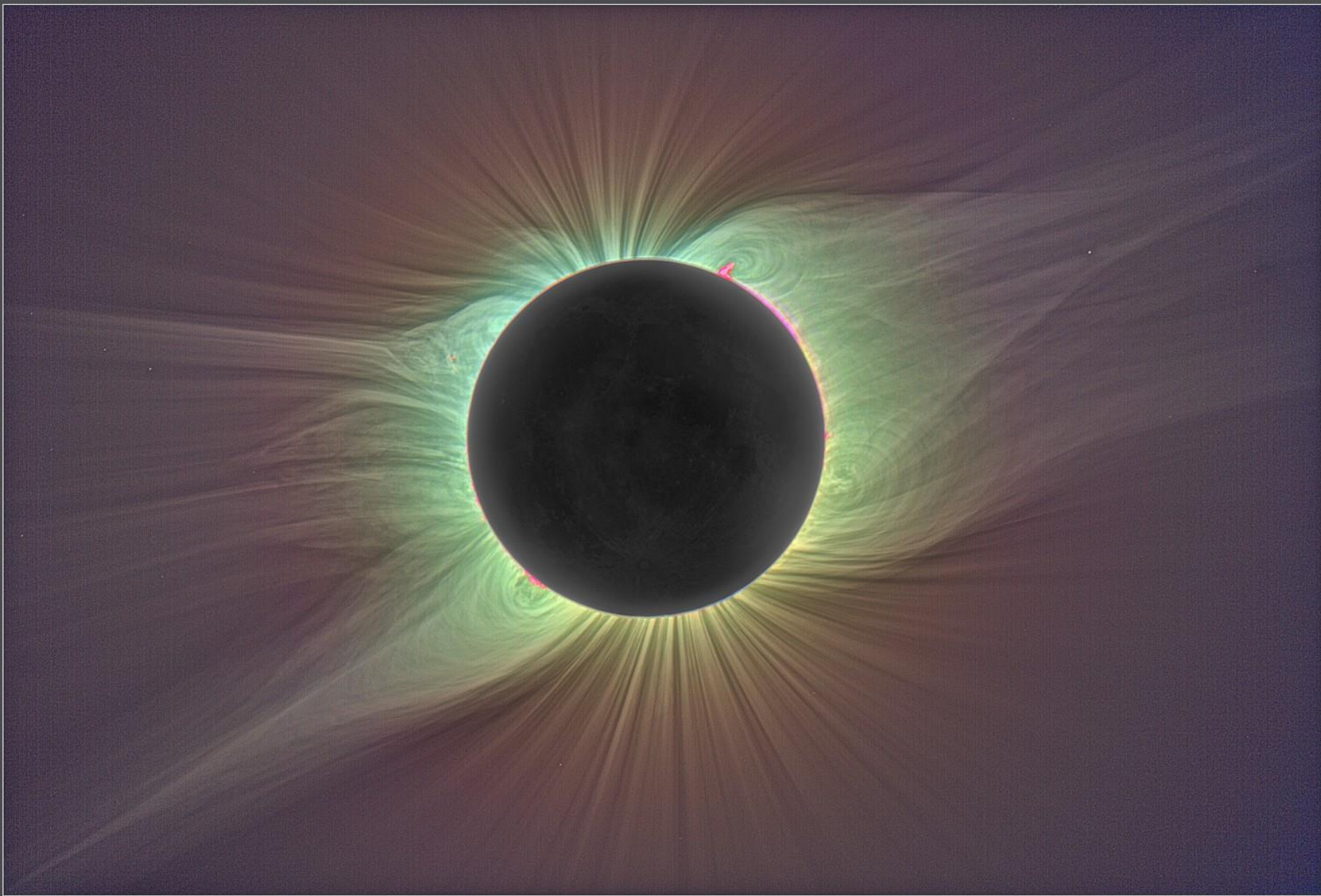


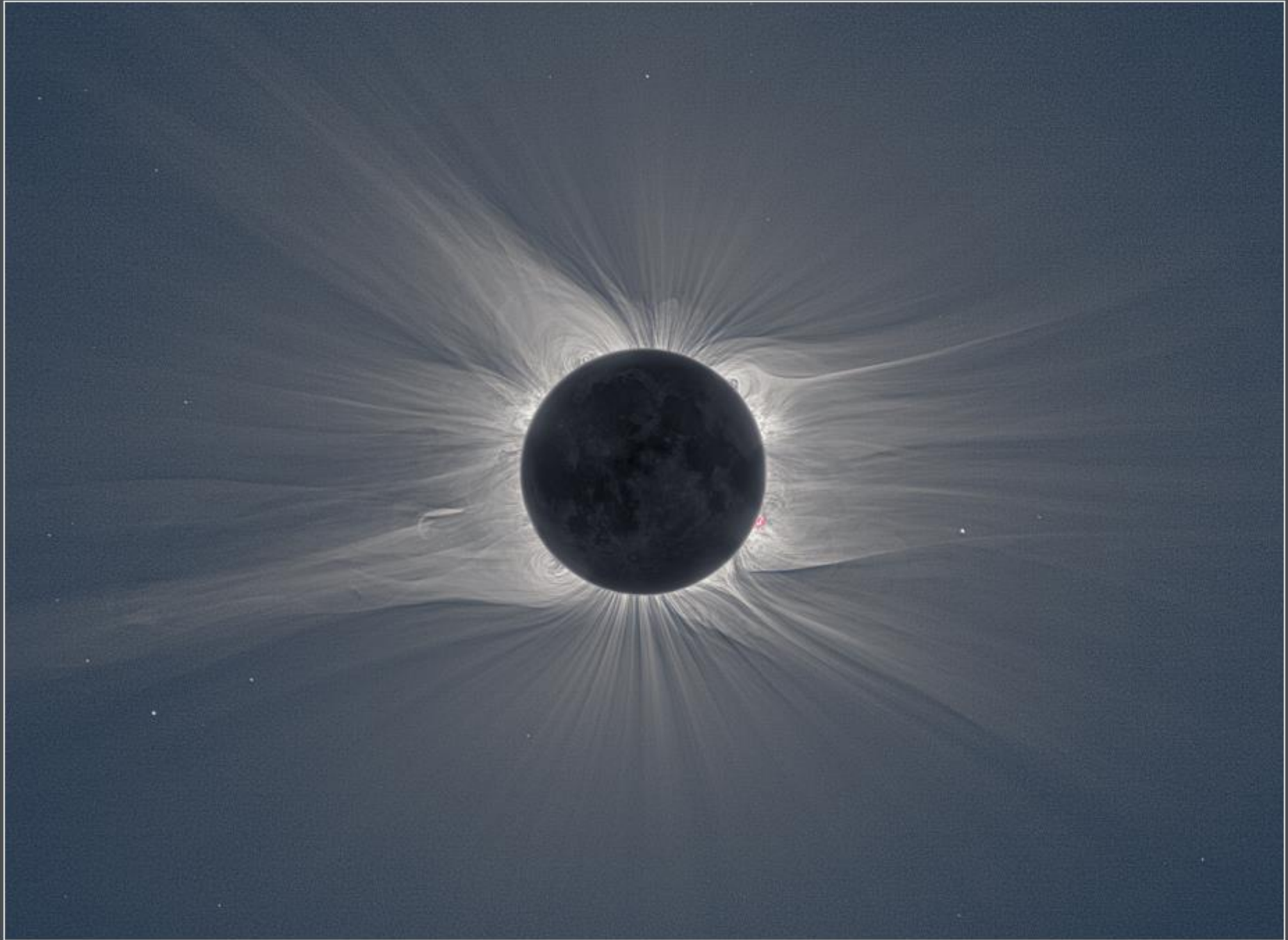
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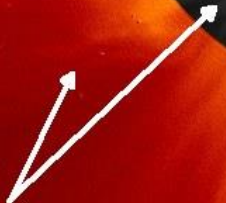




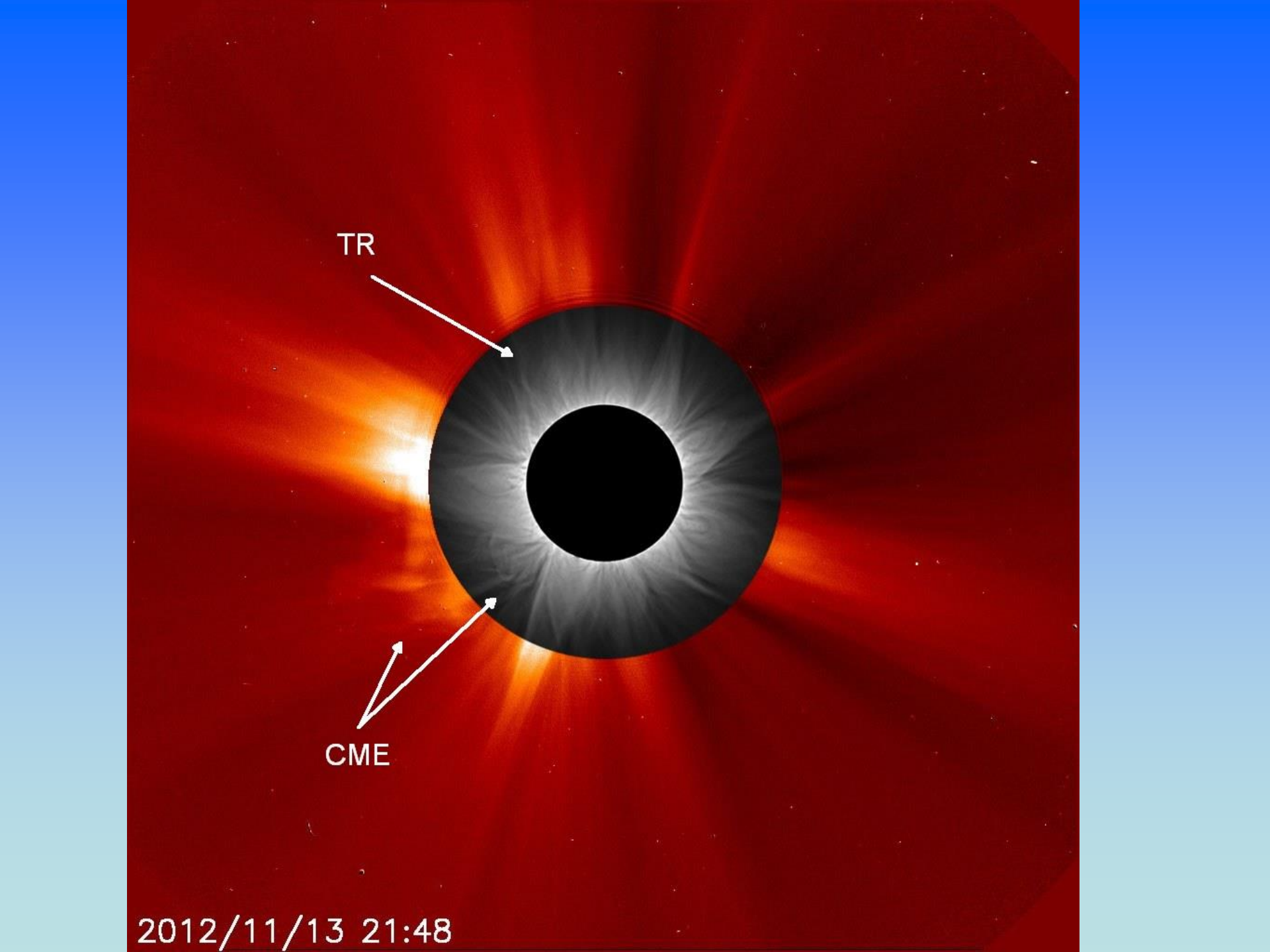
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CME



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Conclusions

- Higher spatial and temporal resolutions are needed
- Closely cooperation between “amateurs” and “professionals” are welcomed and very useful
- New theory for the “magnetic” corona should be available
- Closely cooperation between eclipse and non-eclipse (ground based and space) teams are also needed!
- Eclipse observations of the WLC, even rare, are unreplaceable at the moment!
- To fully understand the solar corona and its role in the heliosphere (solar wind, magnetic field lines) means that scientific observations have to be done in future
- The 2017 eclipse is a wonderful occasion to do this!

Thank you for your attention

***Prepared for the SEC2014
October 25-26, 2014
Cloudcroft, New Mexico,
USA***



For more information

To jubille!

