2020

Standing on the shoulders of giants

european solar telescope

EST

www.**est-east**.eu

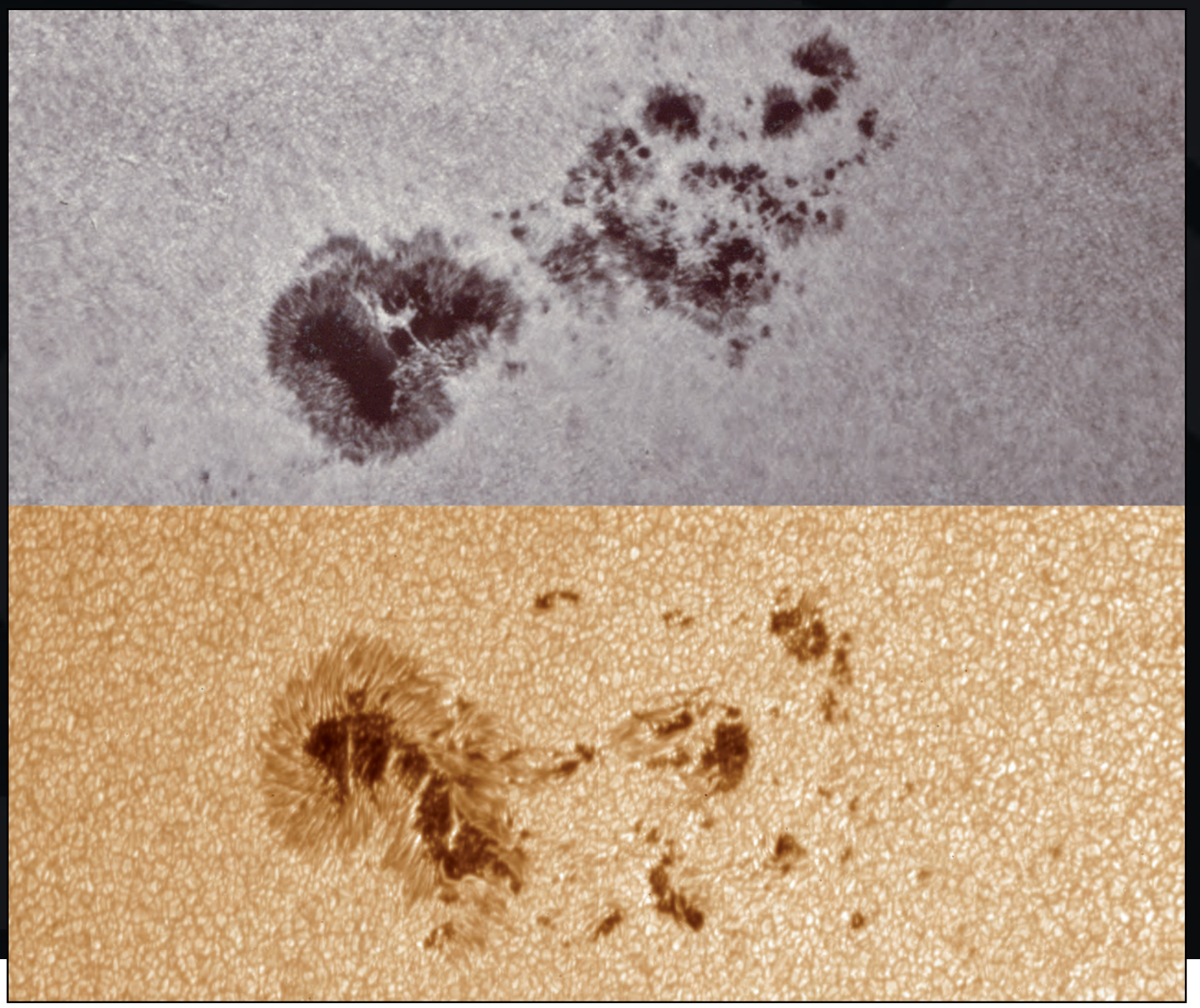
Cover: The solar corona photographed by L. Lindsay and confronted with the prominences observed on 12 December 1871, at Collegio Romano.

"Dall'ultima eclisse (12 Xbre 1871) mediante le belle fotografie ottenute dal Sig. Davis, spedito nelle Indie a spese del Nobile Lord Lindsay, si è riuscito a fare un'idea molto più completa della struttura complicata della corona. Questa struttura è tutta tessuta non di getti o pennacchi rettilinei, ma curvilinei..... Appena io vidi queste figure fui colpito dalla loro simmetria, e subito corsi ad una conclusione importante. Questa era che l'atmosfera solare rappresentata da questa corona, non poteva considerarsi come uno strato in equilibrio disposto con regole statiche, ma che invece era una struttura rigorosamente dinamica."

Angelo Secchi, Sulla distribuzione delle protuberanze solari e loro realazione colle macchie, in Atti dell'Accademia Pontificia de' Nuovi Lincei, Anno XXVI, 27 Aprile 1873. Collection Francesco Berrilli, Memoire di Astronomia del Collegio Romano.

This activity has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No 739500

Solar active regions



■ **Top:** Jules Janssen (1885). **Bottom:** Hinode's Broadband Filter Imager (2009)

Photograph of an active region, taken by Jules Janssen on 22 June 1885 at the Observatoire de Meudon (Paris, France). In addition to the sunspots and pores of the active region, the granulation pattern of the solar surface can clearly be seen. The photograph recorded a very large field of view, and parts of it appear blurred because of the effects of atmospheric turbulence.

The lower panel shows active region 11029 as observed by the Hinode satellite on 27 October 2009 near the edge of the solar disk. The image quality is homogeneous over the entire field of view because the measurements are not affected by the Earth atmosphere. As usual, one of the spots forming the active region is larger and more stable than the other, which appears fragmented into many small pores.

January 4:
Peak of Quadrantids meteor shower (08:20 GMT)

January 13-15:
2nd NCSP DKIST Data Training Workshop,
California State University, Northridge, USA

January 21:
EAST General Assembly, Prague, Czech Republic

JANUARY

MON	TUE	WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI	SAT	SUN
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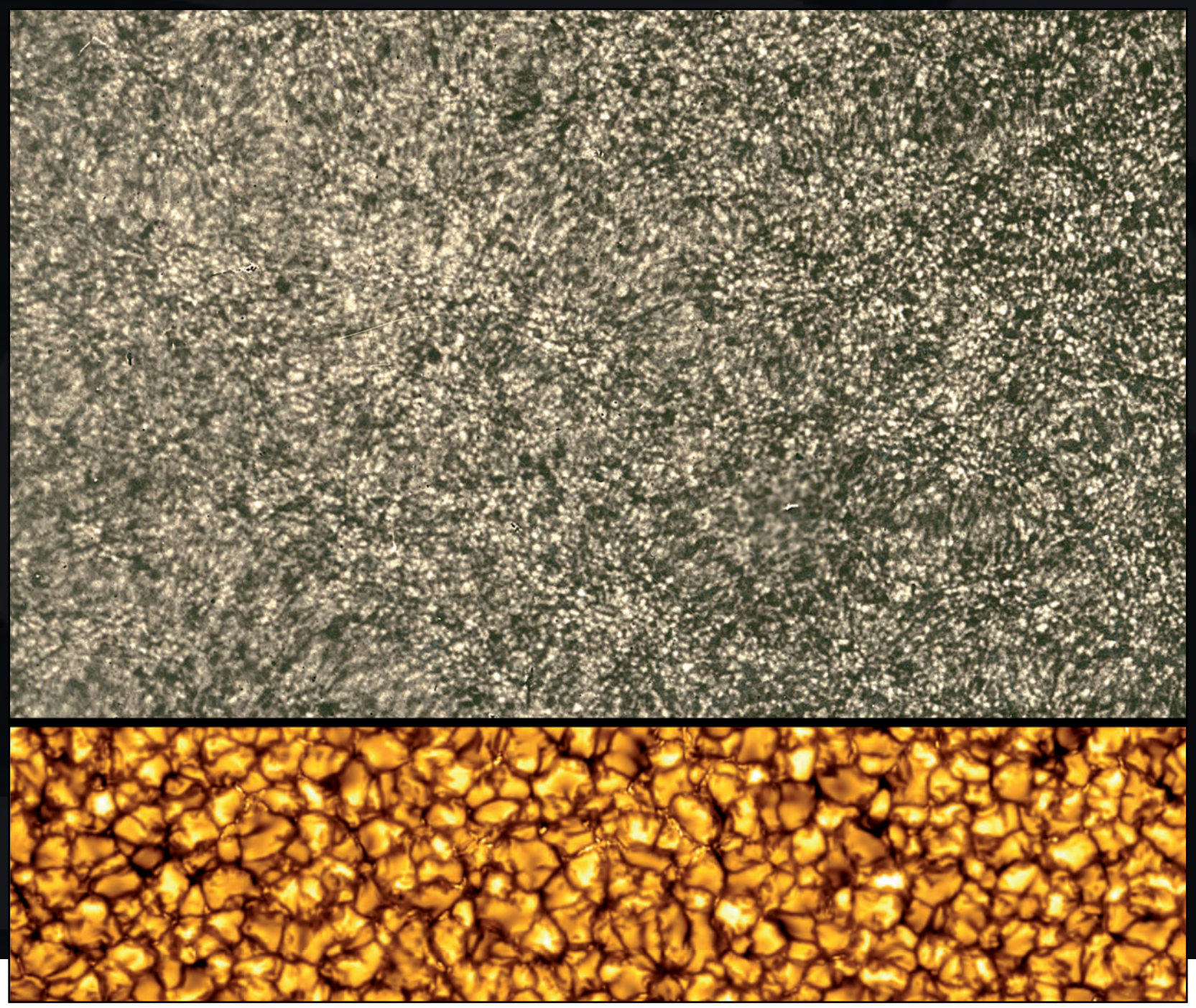
The European Solar Telescope (EST) is the next step in the European quest for a better understanding of the Sun

Solar granulation



■ **Top:** Jules Janssen (1890). **Bottom:** Swedish 1m Solar Telescope (2004)

The image at the top is a particularly good example of early photographs of the solar granulation. It was taken by Jules Janssen at the Observatoire de Meudon (France) on 11 October 1890, from a projection of the solar disk measuring 1.2 meters in diameter. The photograph captured the granulation pattern of the solar surface with surprising detail. However, the field of view is so large that parts of the image appear blurred by turbulence in the Earth's atmosphere.

The CCD image at the bottom shows the solar granulation as seen by the Swedish 1-m Solar Telescope on La Palma (Spain) on 22 August 2004. The observations were acquired using adaptive optics and subsequently reconstructed with sophisticated techniques to reach the diffraction limit of the telescope. In addition to granules and intergranular lanes, one can observe tiny bright points that represent small-scale magnetic fields on the solar surface.

EST

February 3-7:
5th Asia Pacific Solar Physics Meeting, Pune, India

February 5:
Solar Orbiter Launch, Cape Canaveral, USA

February 11:
International Day of Women and Girls in Science

FEBRUARY

MON	TUE	WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI	SAT	SUN
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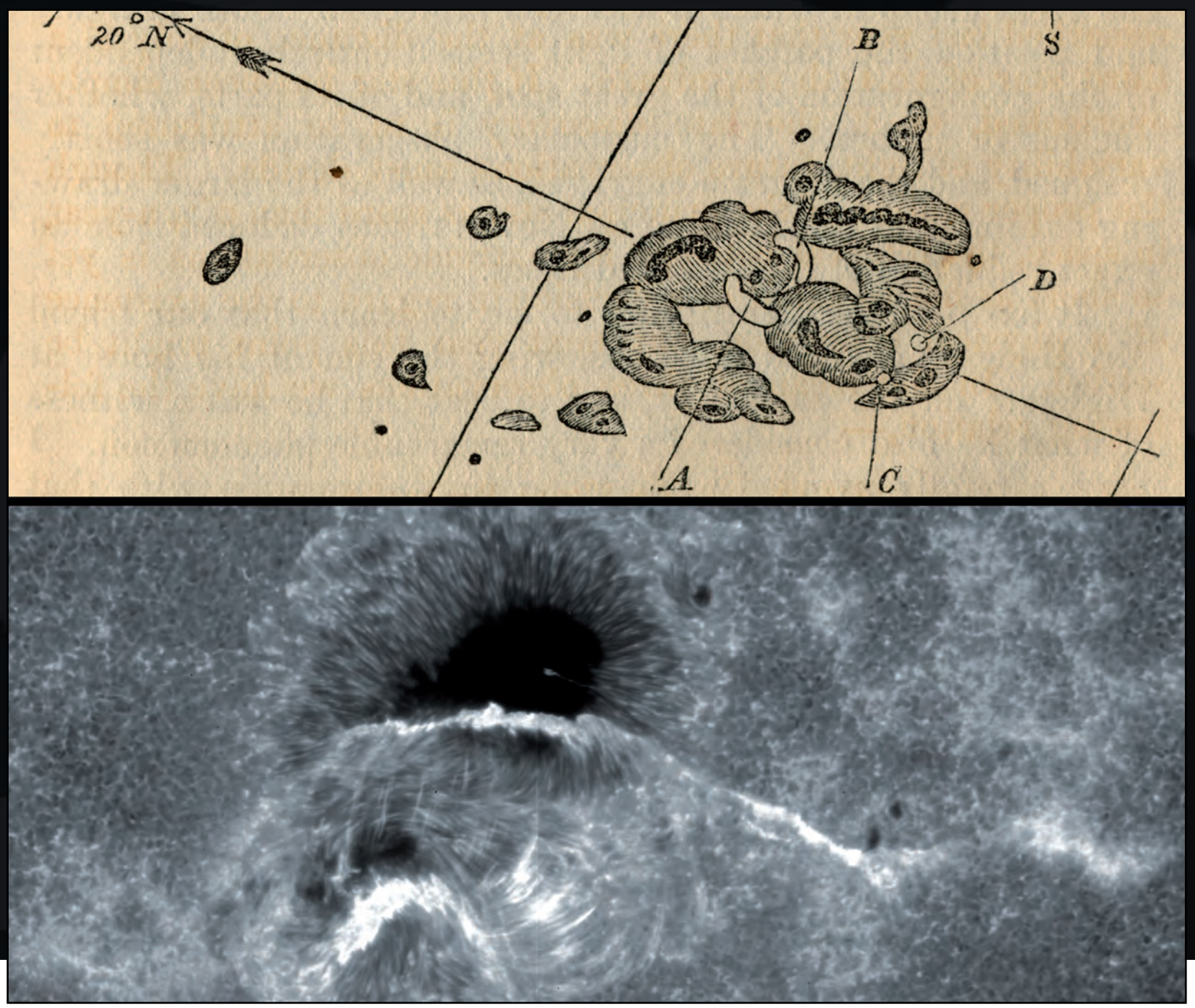
Solar flares



■ **Top:** Richard C. Carrington (1859). **Bottom:** Hinode's Broadband Filter Imager (2007)

Original drawing of the first detection of a solar flare (top). *"I had secured diagrams of all the groups and detached spots, […] when two patches of intensely bright and white light broke out, in the positions indicated in the appended diagram by the letters A and B, and of the forms of the spaces left white. My first impression was that by some chance a ray of light had penetrated a hole in the screen [...], for the brilliancy was fully equal to that of direct sun-light."* Carrington, MNRAS, 20, 13 (1859).

The image at the bottom shows an X 3.4 class flare observed by the Hinode satellite in a complex active region on 13 December 2006. Hinode recorded the flare through a Ca II H filter, which samples the solar chromosphere. The extreme brightening is due to energy released by the reconnection of magnetic field lines.

March 20:
Spring Equinox (03:50 GMT)

March 23-27:
1st Parker Solar Probe Meeting, Laurel, USA

March 31- April 1:
SOLARNET Public Engagement Training Workshop, Northumbria University, UK

MARCH

MON	TUE	WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI	SAT	SUN
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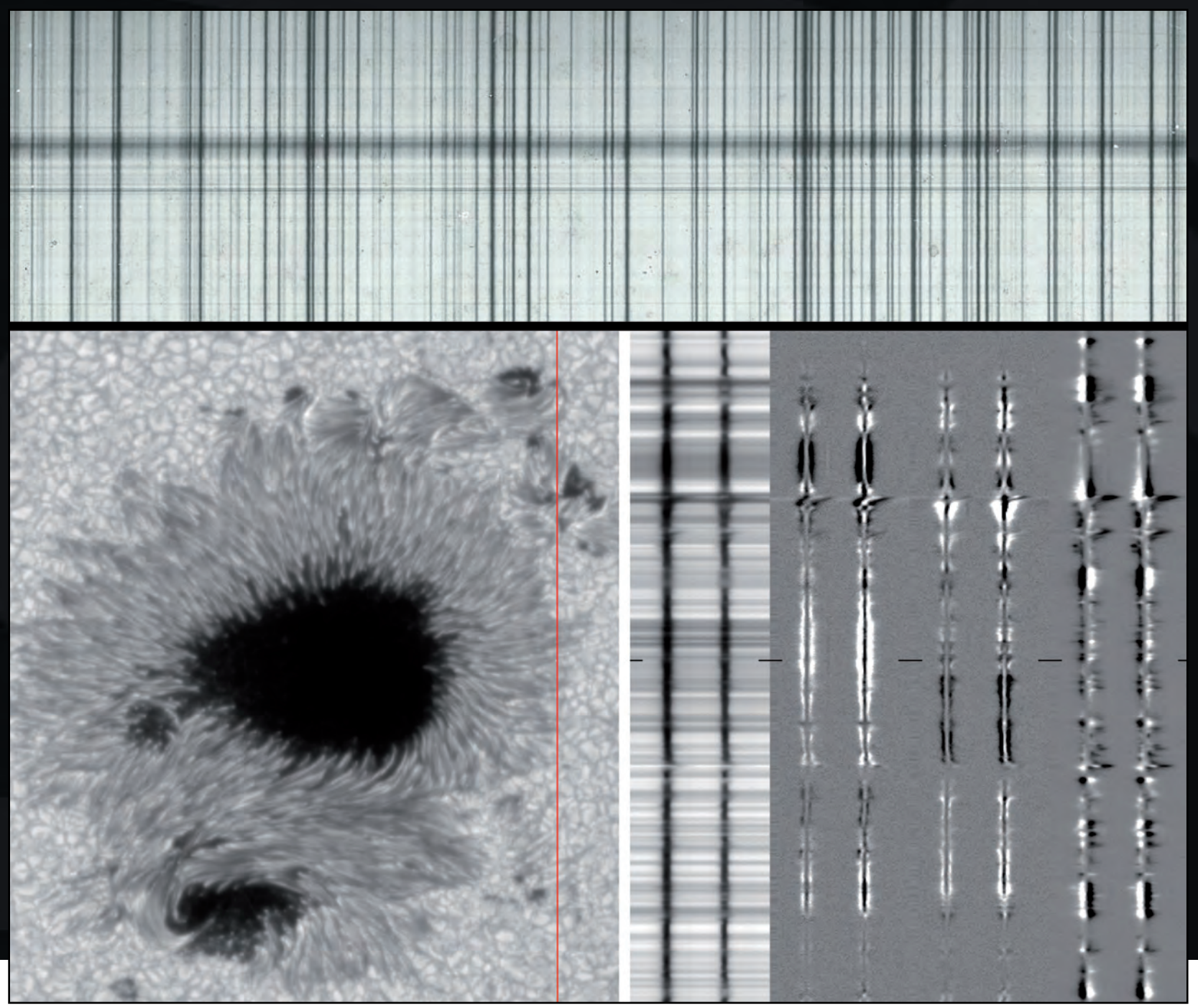
Solar spectroscopy



■ **Top:** John Evershed (1918). **Bottom:** Hinode's Spectro-Polarimeter (2006)

Photograph of the solar intensity spectrum taken by John Evershed at Kodaikanal Observatory (India) on 20 November 1918. The vertical dark lines are spectral absorption lines created by the different chemical elements present in the solar atmosphere. The horizontal dark band is a sunspot. Spectral lines are slightly tilted at the position of the sunspot, due to the existence of horizontal gas motions in the sunspot penumbra – known as Evershed flows.

The lower panel shows modern spectroscopic measurements by the spectropolarimeter aboard the Hinode satellite. The data were taken on 13 December 2006 at the position of a flaring sunspot. The spectrum on the right displays the four polarization states of the light in two iron lines at 630 nm. The spectral resolution of these observations is much higher than that of the spectrum taken by Evershed.

March 31 - April 1:
SOLARNET Public Engagement Training Workshop, Northumbria University, UK

April 22:
Peak of Lyrids meteor shower (07:00 GMT)

April 23:
Peak of Pi Puppids meteor shower (12:00 GMT)

APRIL

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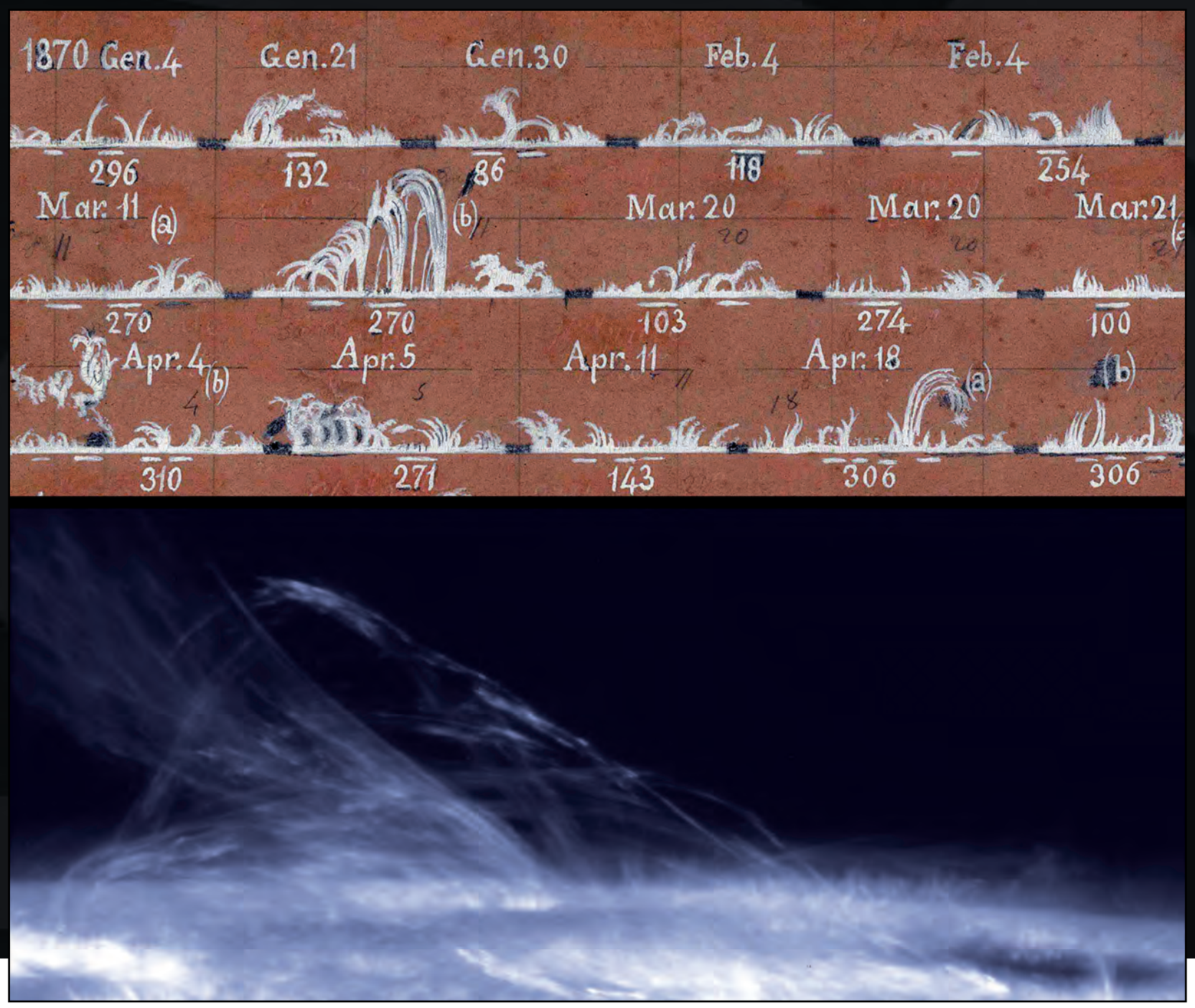
Active region prominences



■ **Top:** Lorenzo Respighi (1870). **Bottom:** Hinode's Broadband Filter Imager (2007)

Prominences observed by Lorenzo Respighi in 1870 at the border of the solar disk near the position of active regions (top). These detailed drawings show the wide range of shapes and sizes of active region prominences. The observations were made using spectroscopic techniques, which were very advanced in Italy at that time. Active region prominences are smaller, shorter, and more dynamical than quiescent prominences occurring far from sunspots.

The lower image shows an active region prominence observed by the Hinode satellite on January 12, 2007. The measurements were taken in the H line of ionized calcium. The prominence exhibits delicate threads that are believed to trace the chromospheric magnetic field. It shows a very rapid evolution, changing shape constantly. The sunspot associated with the prominence can be seen as a dark feature near the right border of the image.

May 3-8:
EGU General Assembly, Vienna, Austria

May 5:
Peak of Eta Aquariids meteor shower (21:00 GMT)

MAY

MON	TUE	WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI	SAT	SUN
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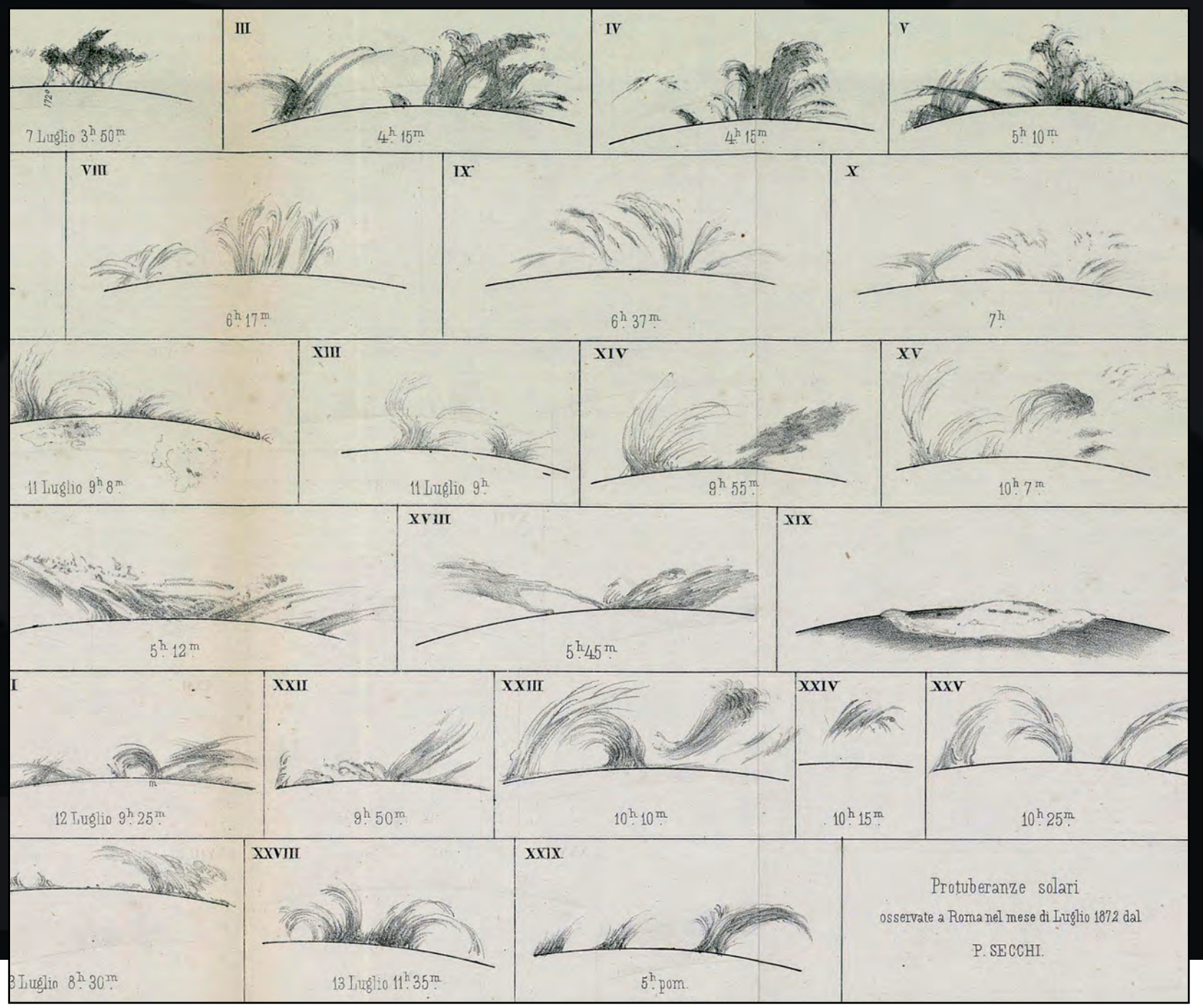
Solar prominences



■ Angelo Secchi (1872)

Prominences observed by Father Angelo Secchi in July 1872 at the border of the solar disk. The measurements were made using spectroscopic techniques, which allowed astronomers to see the prominences out of total solar eclipses. Indeed, spectroscopy made it possible to monitor the solar limb daily in search for prominences and other solar phenomena. Their number was found to vary in phase with the solar cycle. Prominences were thought to be eruptions of the chromosphere, coming in different shapes and sizes. Secchi proposed a complex classification consisting of several groups.

Due to their strong emission in chromospheric lines, notably the H-alpha line, prominences were soon considered to be made of hot gas. This view stands today, although we also know that prominences are much cooler than the coronal plasma where they are embedded.

June 14-19:
SPIE Astronomical Telescopes, Yokohama, Japan

June 20:
Summer Solstice (21:43 GMT)

June 21:
Annular solar eclipse

June 22-26:
Cool Stars 21, Toulouse, France

JUNE

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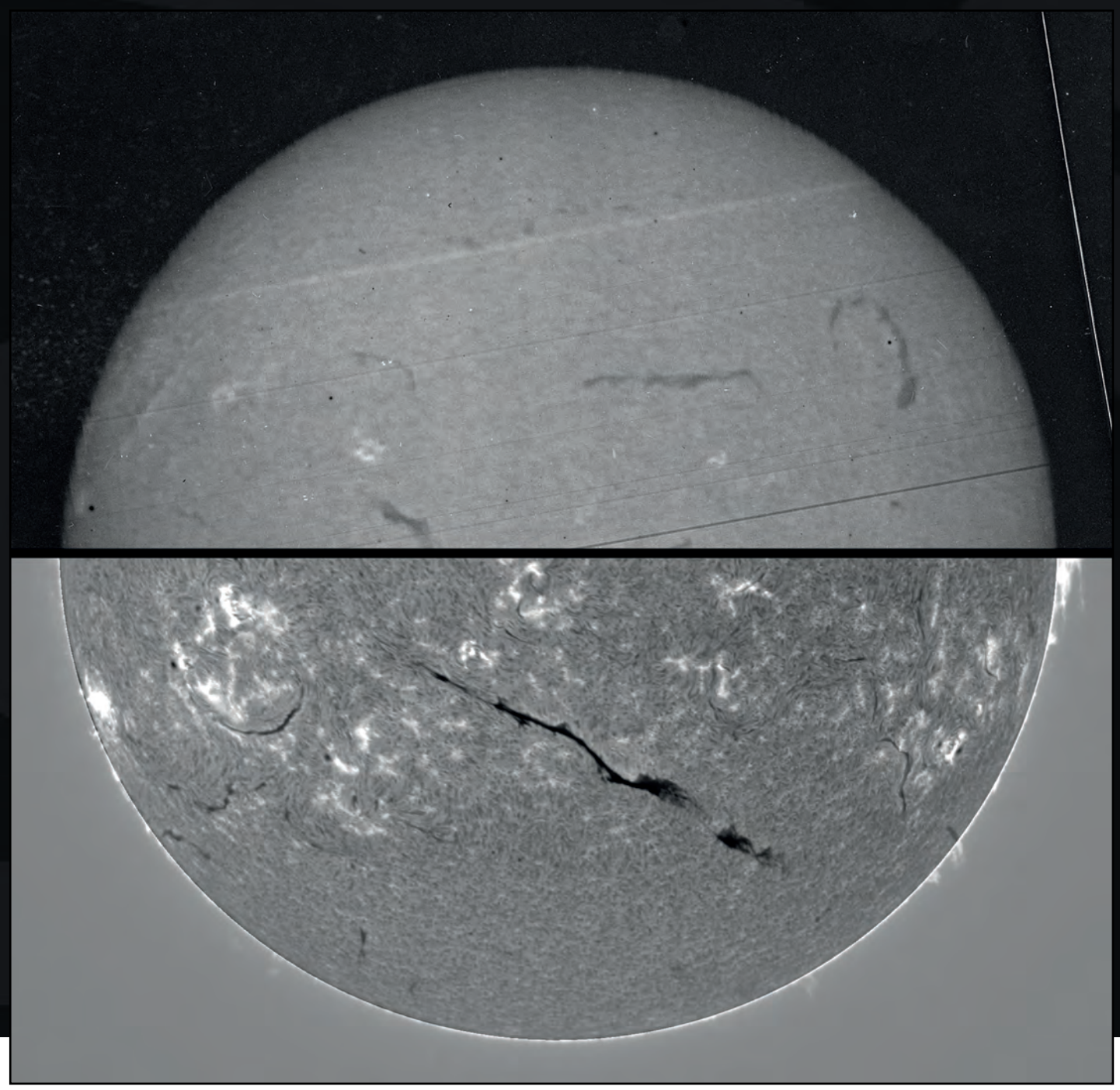
Solar filaments



■ **Top:** Observatoire de Meudon (1909). **Bottom:** ChroTel (2011)

The photograph on top is one the first H-alpha spectroheliograms recorded at Observatoire de Meudon (Paris, France). Taken on 15 June 1909, it shows the chromosphere of the Sun. The dark long structures visible on the solar disk are filaments. When observed at the limb, filaments are called prominences and appear bright.

The CCD image at the bottom shows the solar chromosphere in H-alpha as recorded by the Chromospheric Telescope (ChroTel) on 15 November 2011. Both dark filaments and bright prominences can be seen. The much higher contrast is partly due to the application of new image processing techniques. ChroTel observes the full disk of the Sun at 3 different wavelengths: H-alpha, Ca II K, and He I 1083 nm. This small robotic telescope is located at the Observatorio del Teide on Tenerife (Spain) and was developed by the KIS (Germany) and HAO (USA).

EST

July 5:
Penumbral lunar eclipse

July 27-30:
Waves and Instabilities in the Solar Atmosphere, Newcastle, UK

July 28-31:
Hinode-14 Science Meeting, Washington DC, USA

JULY

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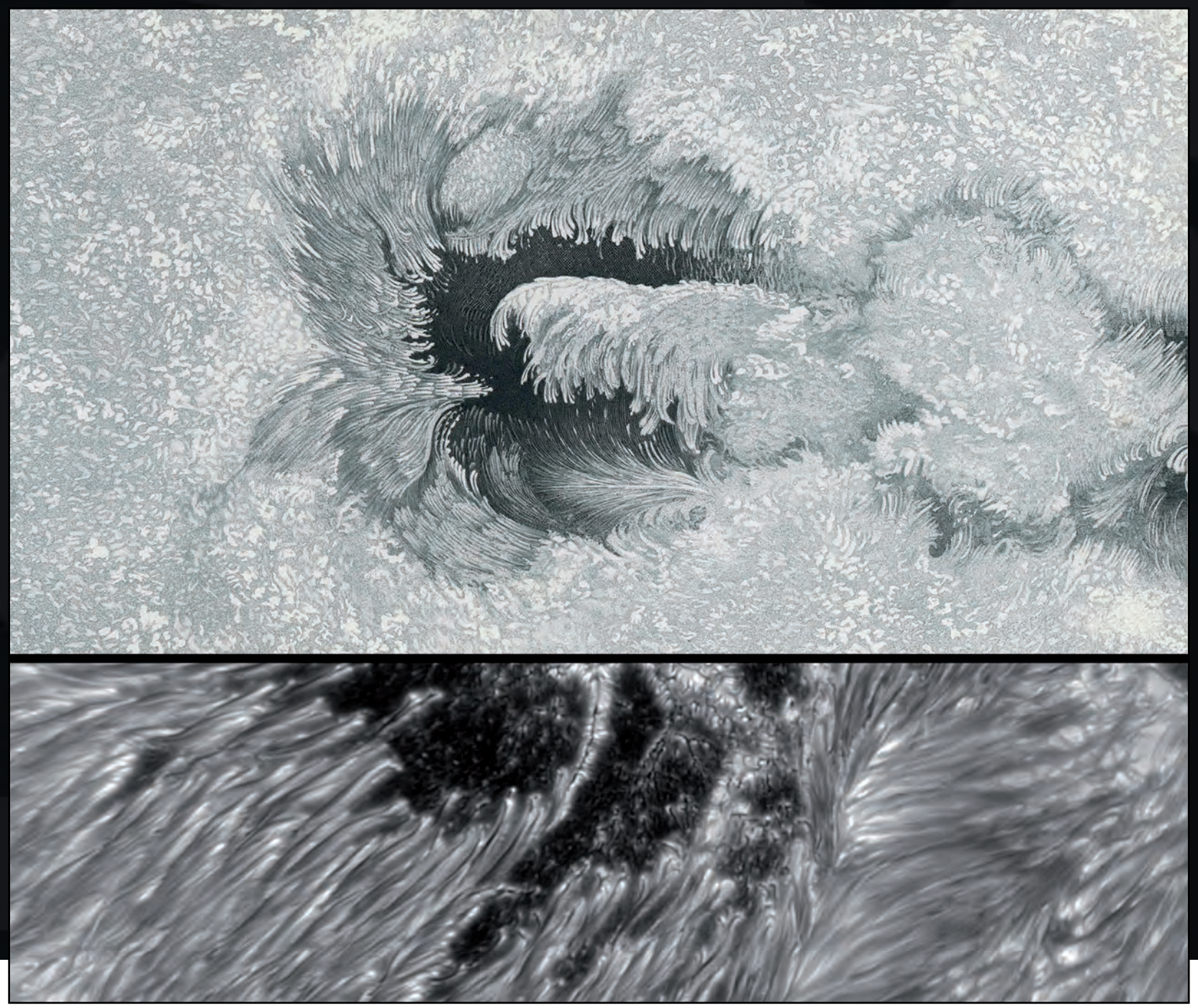
Sunspot penumbra



■ **Top:** Samuel Langley (1873). **Bottom:** Goode Solar Telescope (2015)

The image at the top is a remarkable drawing of a sunspot created by Samuel Langley in December 1873, using the 13-inch Fitz-Clark refractor of the Allegheny Observatory (Pennsylvania, USA). It shows a very detailed view of the filamentary structure of the sunspot penumbra. Bundles of individual filaments can be seen protruding into the dark umbra. Penumbral filaments are extremely narrow, so excellent atmospheric conditions had to occur for Langley to identify them.

The lower image shows penumbral filaments in extraordinary detail, as observed with the 1.6-m Goode Solar Telescope at Big Bear Solar Observatory (California, USA) on 20 June 2015. At high spatial resolution, penumbral filaments exhibit central dark cores and bright heads. Scientists still debate the origin of penumbral filaments and their relation to the sunspot magnetic field.

August 12:
Peak of Perseids meteor shower (10-13 GMT)

August 15-23:
43rd COSPAR Scientific Assembly, Sydney, Australia

August 25-29:
IAU Symposium 365, Dynamics of Solar and Stellar Convection zones and Atmospheres, Moscow, Russia

AUGUST

MON	TUE	WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI	SAT	SUN
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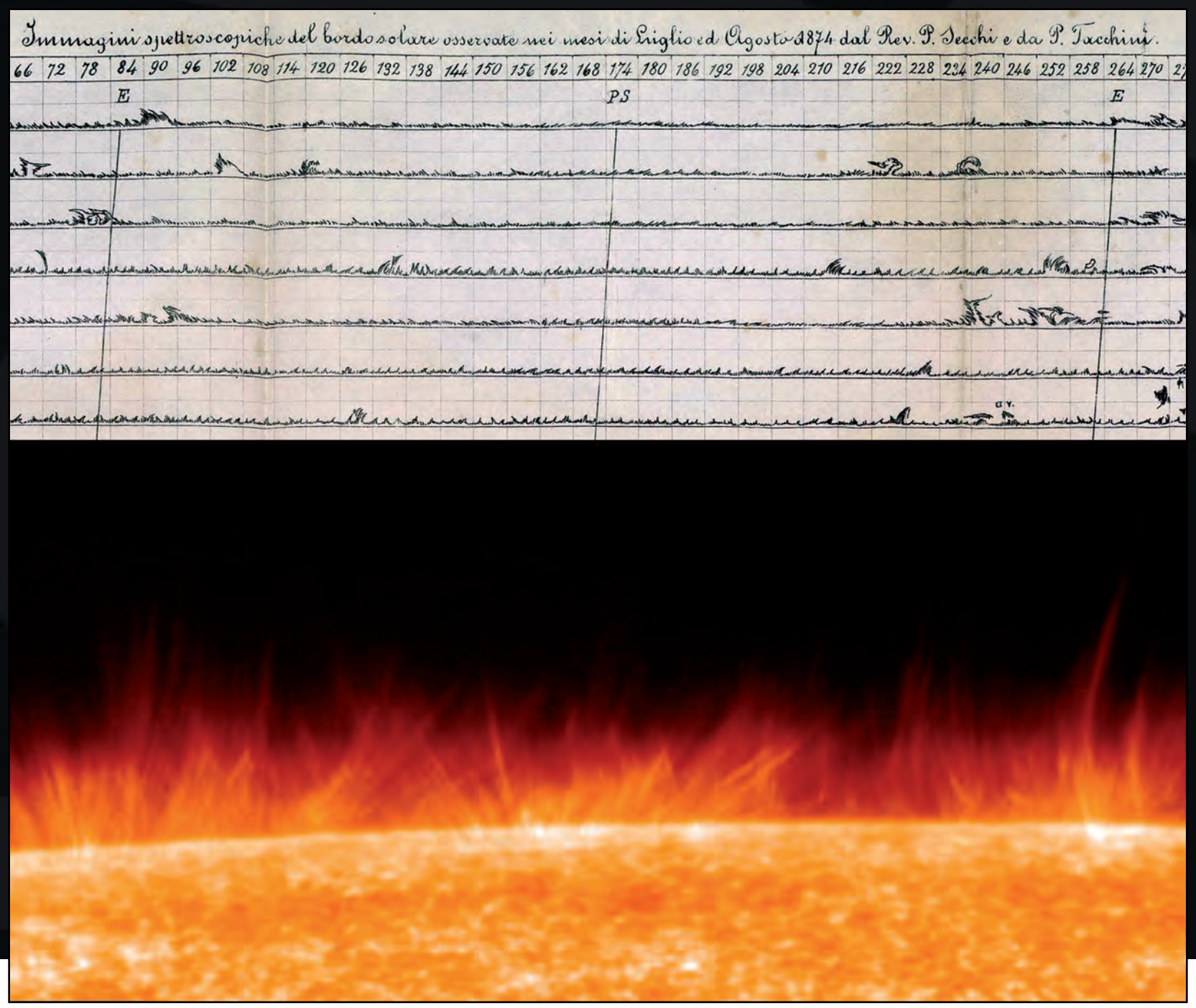
Solar spicules



■ **Top:** Angelo Secchi and Pietro Tacchini (1874). **Bottom:** Hinode Broadband Filter Imager (2007)

Solar spicules were discovered by Angelo Secchi in the 19th century, observing the Sun by spectroscopic means. He called them "prateria ardente", which means "burning field" in Italian. The image at the top shows careful drawings of spicules and small prominences on the solar limb done by Angelo Secchi and Pietro Tacchini in 1874. By that time, systematic observations of the solar limb were made daily in Rome, Palermo and Padova (Italy), recording incredible detail.

The lower image shows high-resolution observations of spicules taken by the Japanese Hinode satellite on 8 November 2007. The Broadband Filter Imager was used to study the rapid evolution of spicules at the solar limb in the Ca II H spectral line. Spicules are ubiquitous jets of plasma in the chromosphere, but their origin is not fully understood.

September 7-11:
16th European Solar Physics Meeting, Turin, Italy

September 22:
Autumn equinox (13:31 GMT)

SEPTEMBER

MON	TUE	WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI	SAT	SUN
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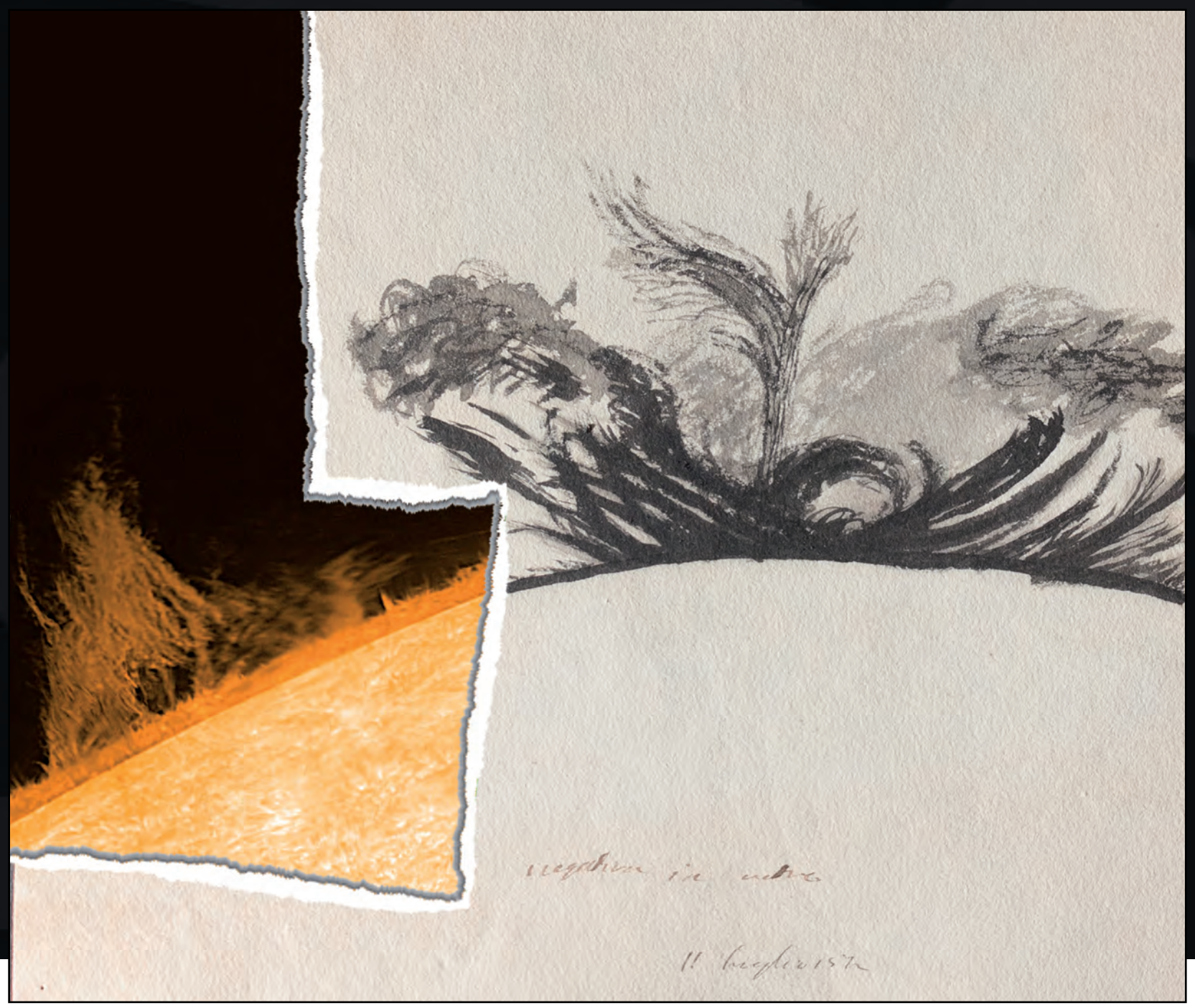
Solar prominences



■ **Right:** Angelo Secchi (1871). **Left:** Hinode's Narrowband Filter Imager (2007).

Solar prominence observed by Father Angelo Secchi at Collegio Romano (Rome, Italy) in 1871. Secchi studied the fine structure of prominences, estimated their size, and hypothesized about their nature. He also recognized the link between sunspots, faculae and prominences, reporting that "it is certainly a great fact that there are never spots without faculae. And now we know that the spots and the faculae are accompanied by difference in height in the photosphere and by luminous jets" - prominences.

The image on the left shows a prominence observed by the Hinode satellite in the center of the H-alpha line on 25 April 2007. The H-alpha observations sample gas at chromospheric temperatures. The delicate fine details of the prominence are very noticeable, as is the large dark cavity that forms at its base. Some of these features were already observed by Secchi and other fellow astronomers.

October 8:
Peak of Draconids meteor shower (12:30 GMT)

October 12-16:
2020 SDO Science Workshop, Vancouver, Canada

October 21:
Peak of Orionids meteor shower (05:30 GMT)

OCTOBER

MON	TUE	WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI	SAT	SUN
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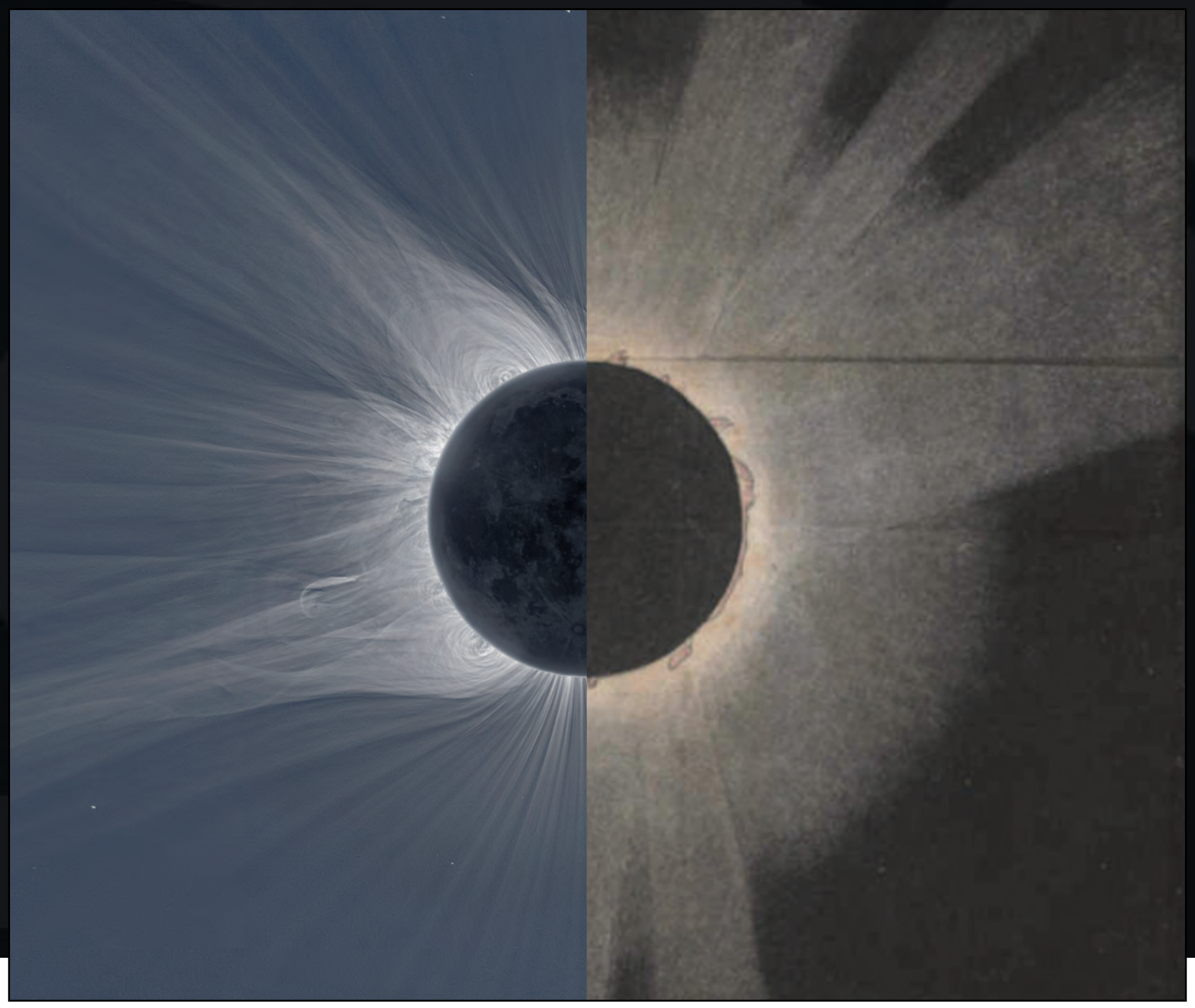
Solar corona



■ **Left:** Total solar eclipse of 2010. **Right:** Total solar eclipse of 1860.

Angelo Secchi organized a scientific expedition to Desierto de Las Palmas (Spain) to observe the total solar eclipse of 18 July 1860. The photographs he took showed prominences at the edge of the solar disk (the reddish features visible on the right panel) and much longer coronal streamers. The same prominences were observed by Warren De La Rue from Rivabellosa, 500 kilometers away from Secchi's site. This demonstrated that prominences were indeed solar features and not optical illusions.

The left panel displays the solar corona as recorded by an international team in Tatakoto Atoll (French Polynesia) during the total eclipse of 11 July 2010. Coronal loops and streamers can be seen with incredible detail. This view of the corona is possible thanks to the combination of photographs with different exposure times and the application of sophisticated image processing techniques.

November 12:
Peak of Northern Taurids meteor shower (05:00 GMT)

November 17:
Peak of Leonids meteor shower (11:00 GMT)

November 30:
Penumbral lunar eclipse

NOVEMBER

MON	TUE	WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI	SAT	SUN
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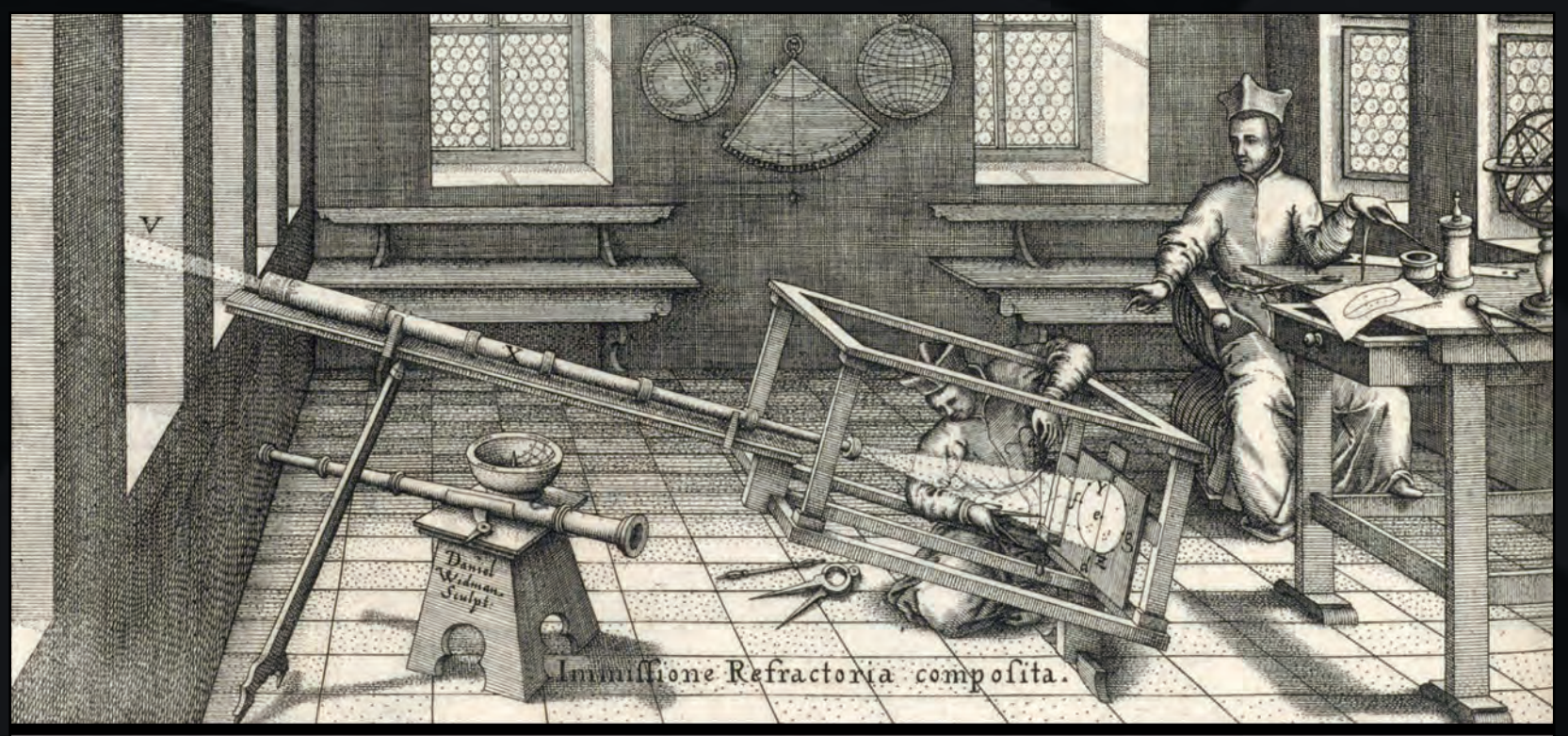
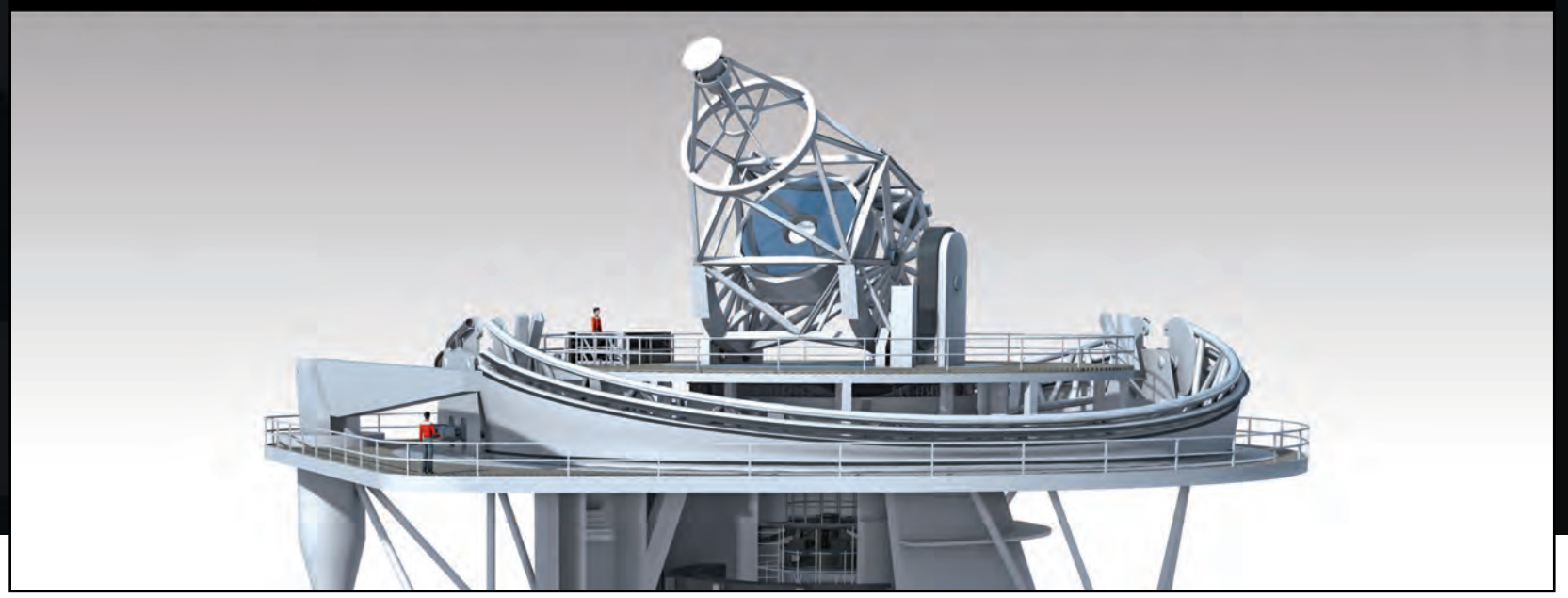
Solar telescopes





■ **Top:** Christoph Scheiner's telescope (circa 1625). **Bottom:** European Solar Telescope (2027).

Telescope used by Christoph Scheiner to trace sunspots in Rome (Italy) around 1625. The image of the Sun created by the instrument was projected on a screen, over which sunspots could be drawn accurately. Scheiner's telescope was a small refractor made up of lenses. The illustration is from the book "Rosa Ursina" by Scheiner.

The lower image shows a rendering of the future European Solar Telescope (EST). With a primary mirror of 4 meters, it will be the largest telescope ever built in Europe. The EST consortium has proposed to install it at Observatorio del Roque de Los Muchachos on La Palma (Spain). Construction will start towards the end of 2021. The EST design is optimized to study the magnetic and dynamic coupling of the solar atmosphere through multi-wavelength observations. EST will be equipped with state-of-the-art instrumentation, including spectropolarimeters based on integral field units.

December 14:
Total solar eclipse

December 14:
Peak of Geminids meteor shower (00:50 GMT)

December 14-20:
Dynamic Sun III, Villarrica, Chile

December 21:
Winter solstice (10:02 GMT)

DECEMBER

MON	TUE	WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI	SAT	SUN
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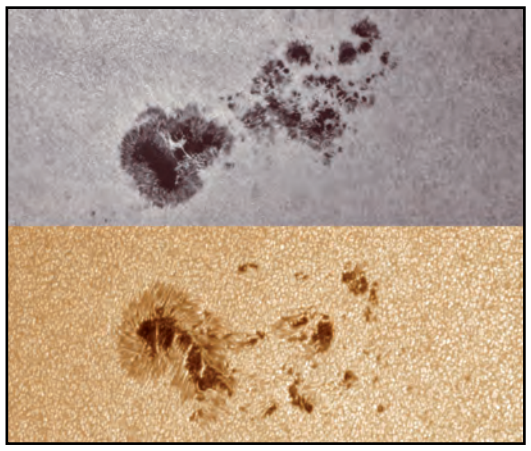
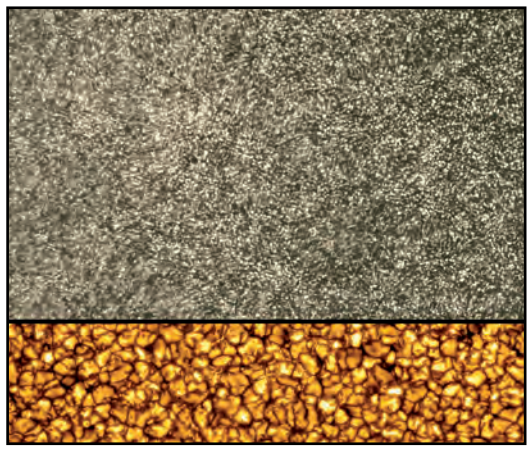


JANUARY

Solar active regions

Top: Jules Janssen, *"Études des surfaces solaires", Observatoire de Meudon. Courtesy Jean-Marie Malherbe*

Bottom: *Hinode (ISAS/JAXA, NAOJ, NASA, STFC, ESA)*

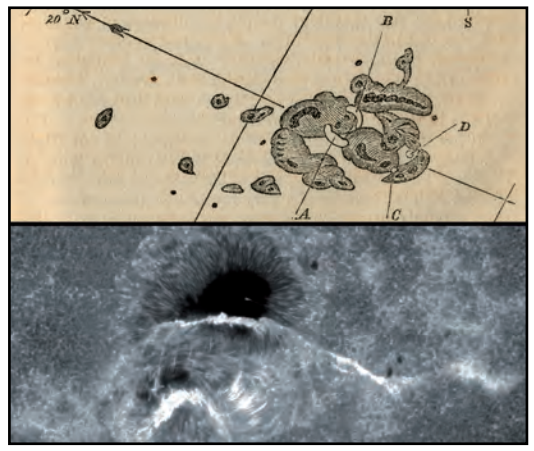


FEBRUARY

Solar granulation

Top: *Observatoire de Meudon. Courtesy Jean-Marie Malherbe*

Bottom: *Michiel van Noort (ISP) and Luc Rouppe van der Voort (ITA)*

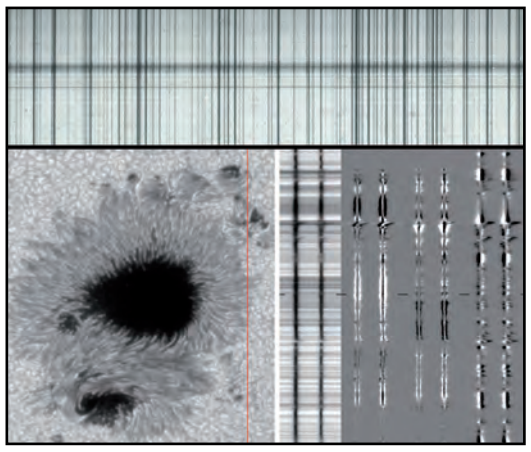


MARCH

Solar flares

Top: *Richard Carrington, Monthly Notices of the Royal Astronomical Society, 20, 13 (1859)*

Bottom: *Hinode (ISAS/JAXA, NAOJ, NASA, STFC, ESA)*

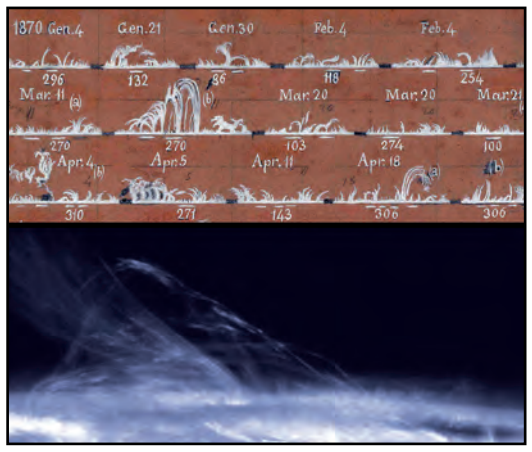


APRIL

Solar spectroscopy

Top: *The Science Museum Group, John Evershed Archive, EVER/A/1/E203*

Bottom: *Hinode (ISAS/JAXA, NAOJ, NASA, STFC, ESA)*

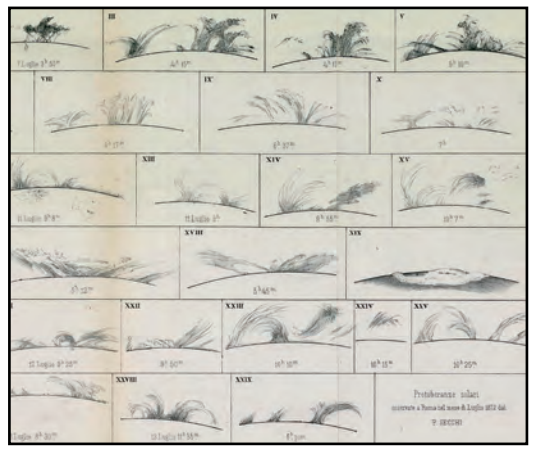


MAY

Active region prominences

Top: *© INAF Museo Astronomico Copernicano. Courtesy Ilaria Ermolli, Marco Ferrucci (INAF-OAR)*

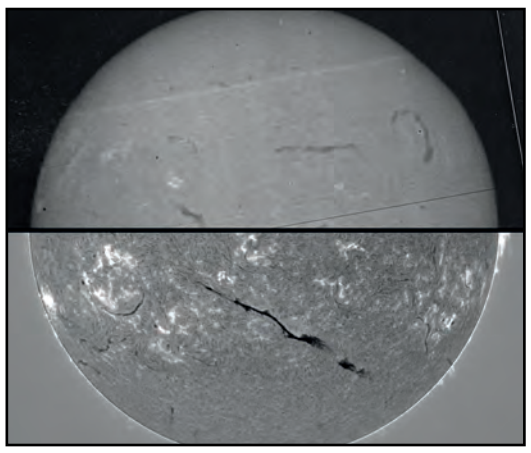
Bottom: *Hinode (ISAS/JAXA, NAOJ, NASA, STFC, ESA). Courtesy Luis Bellot Rubio (IAA-CSIC)*



JUNE

Solar prominences

Memorie della Società degli Spettroscopisti Italiani (1872). Courtesy Niedersächsische Staats - und Universitätsbibliothek Göttingen (4 ASTR I, 6725:14)

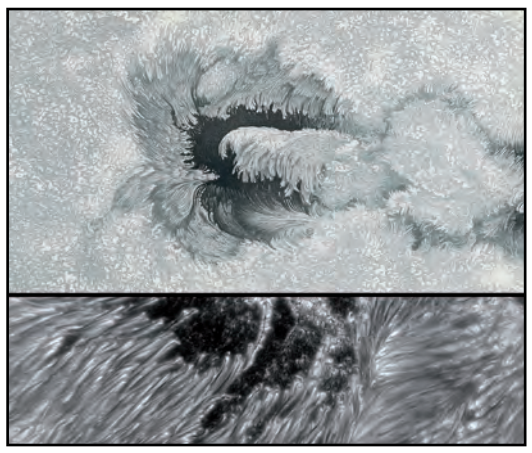


JULY

Solar filaments

Top: *Observatoire de Meudon. Courtesy Jean-Marie Malherbe.*

Bottom: *Christoph Kuckein, Meetu Verma, Carsten Denker (AIP)*

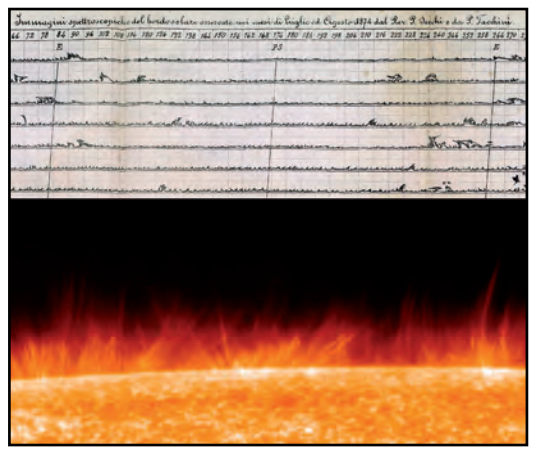


AUGUST

Sunspot penumbra

Top: *Courtesy Jim Hughes (www.codex99.com/illustration/119.html)*

Bottom: *Courtesy Wenda Cao (Big Bear Solar Observatory, USA)*



SEPTEMBER

Solar spicules

Top: *Memorie della Società degli Spettroscopisti Italiani (1876). Courtesy Niedersächsische Staats - und Universitätsbibliothek Göttingen (4 ASTR I, 6725:5)*

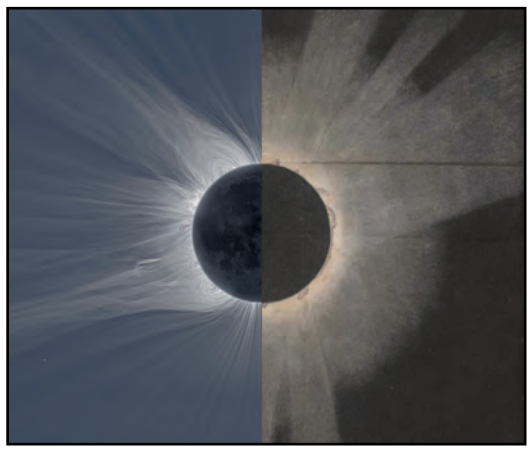
Bottom: *Hinode (ISAS/JAXA, NAOJ, NASA, STFC, ESA). Courtesy Joten Okamoto (NAOJ, Japan)*

OCTOBER

Solar prominences

Right: *INAF Osservatorio Astronomico di Roma. Courtesy Ilaria Ermolli and Marco Ferrucci (INAF-OAR)*

Left: *Hinode (ISAS/JAXA, NAOJ, NASA, STFC, ESA). Courtesy Dick Shine (LMSAL)*

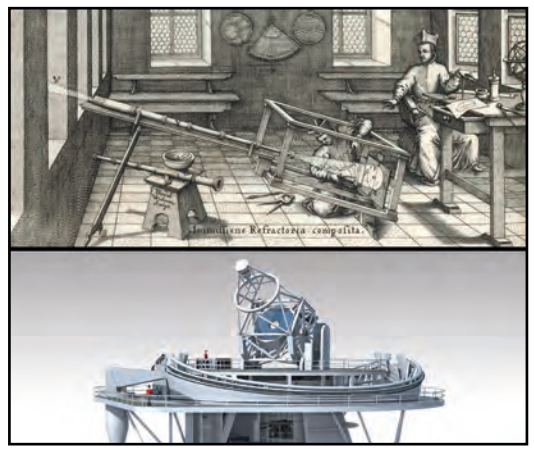


NOVEMBER

Solar corona

Right: *© INAF. Angelo Secchi, Tra Cielo e Terra. Courtesy Ilaria Ermolli (INAF-OAR)*

Left: *Miloslav Druckmüller, Martin Dietzel, Shadia Habbal, Vojtech Rušin*



DECEMBER

Solar telescopes

Top: *From "Rosa Ursina sive Sol" by Christoph Scheiner, 1626, p. 150. Scanned from the original at Houghton Library, Harvard University*

Bottom: *EST project. Courtesy Gabriel Pérez (IAC)*