BERNARD LYOT
SCIENTIFIC ACHIEVEMENTS between 1939 and 1952.

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BERNARD LYOT (1897-1952).

THE PHASE CONTRAST METHOD

- **The idea of phase contrast method went to Bernard Lyot around 1940. His purpose was initially to test the lenses for coronographs. He worked the technique with Maurice Françon.**
- **The lens is illuminated by a point source which is focused on a absorbing mask reducing more than a thousand time the intensity. Il also shifts the phase for a quarter of wave.**

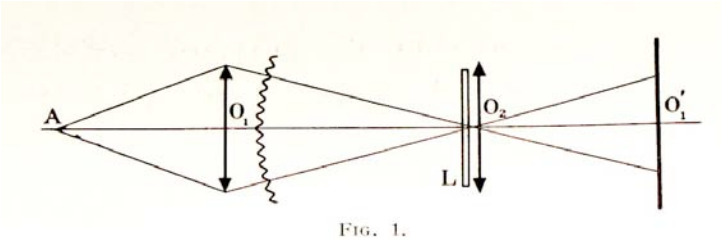


FIG. 1.

- A field lens covers the field and forms an image of the objective. This image is a combination of the faint image of the objective uniformly illuminated (formed through the mask) and an image formed by the light scattered by the faint defects of the lens.
- These two images interferes. The small defects which are phase shifted a quarter of a wave add their amplitudes to those of the uniform image, thus enhancing their contrasts.

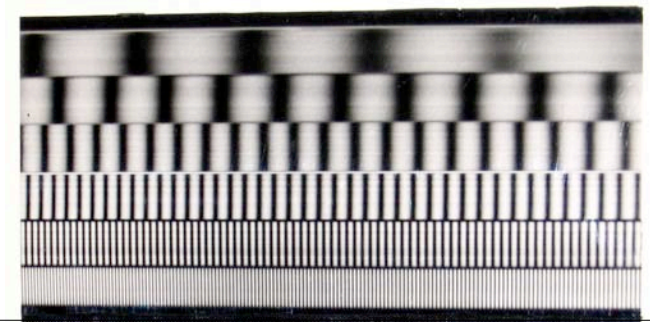
Phase contrast image of small. defects of a lens.

Phase contrast mask . with phase shifter.

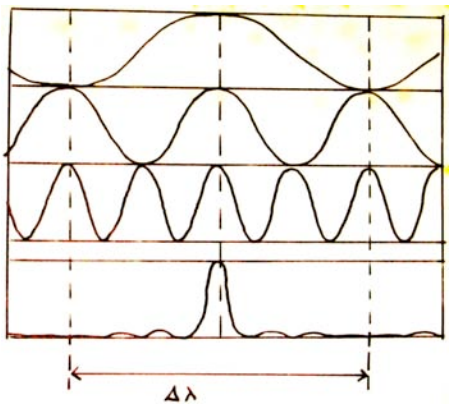
THE BIREFRINGENT FILTER

- Bernard Lyot devised the principle of the
- birefringent filter in 1933.

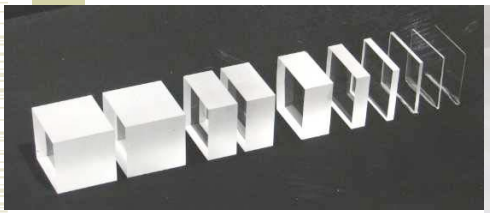
- A plate of birefringent material (quartz) is placed between two polarizers (with axes properly oriented). A source of light observed through the plate with a spectroscope shows a spectrum striated with dark and bright strips as a grid (channelled spectrum).



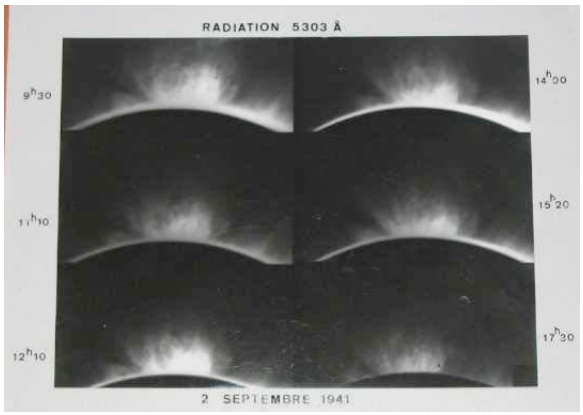
Several such plates are added, of thicknesses increasing by factor two. The channelled spectra produces by each plates imbricate each others so that only one transmitted band remains.



Bernard Lyot built himself a filter based upon his principle in 1939. He used it in 1940 and 1941 to analyze the solar corona.



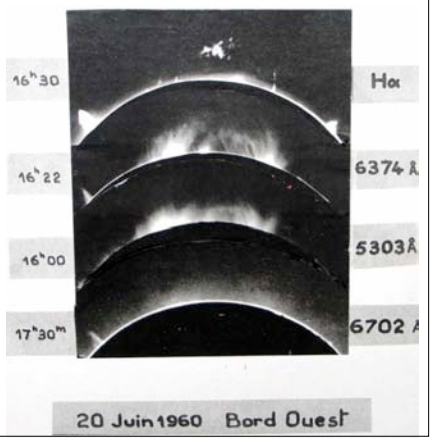
In 1941 and 1942, Lyot used his filter with the coronograph at Pic du Midi to record images of the monochromatic emissions in the solar corona.



- Monochromatic images of the radiation 530.3 nm emitted by the solar corona.

After Lyot died in 1952, the technique was still improved. New types birefringent filters were operated at Pic du Midi to record the solar corona in several radiations.

- Analysis of the temperature distribution within the corona medium.



The next step for Bernard Lyot was to achieve a still narrower birefringent filter, in order to analyze the solar chromosphere with its hydrogen emission at H alpha.

- Lyot designed the instrument in 1947 and tested his prototype at Meudon Observatory in 1948.

The solar chromosphere display very energetic processes concentrated on active regions, with emission of radiations and particles, able to reach the earth atmosphere and deserving a monitoring.

LA CHROMOSPHERE SOLAIRE EN Hα AVEC L'HELIOGRAPHE MONOCHROMATIQUE A FILTRE POLARISANT DE BERNARD LYOT.

Several observatories were willing to use such filter and Lyot decided to ask a private company to design commercially the birefringent filter.

From 1949 to 1965, twenty nine Lyot's filters or derived versions were designed by the French company OPL and used for solar observations in several stations through the world.

Details about the filter

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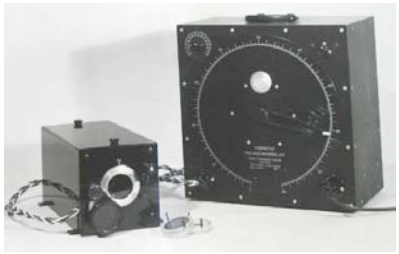


The OPL filter and it thermostat.

THE AUTOMATED HELIOGRAPHIC TELESCOPE

The success of the birefringent filter incited International Astronomical Union to organize a world wide survey of the solar chromosphere activity.

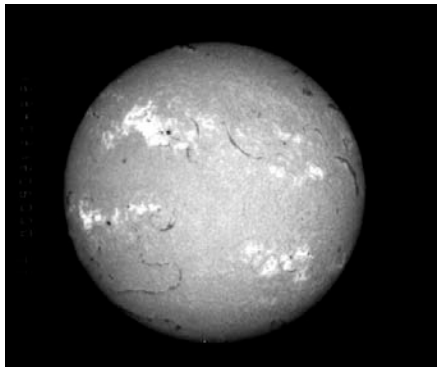
B. Lyot conceived an automated telescope taking in sequences chormospheric images on films each minutes through the day.

The prototype of the instrument was designed by Henri Grenat at the time of the death of Lyot in 1952 and entered into operation at Meudon Observatory in 1953.

- The instrument was operated routinely at Meudon to record the chromospheric solar activity during twelve years, until 1964.

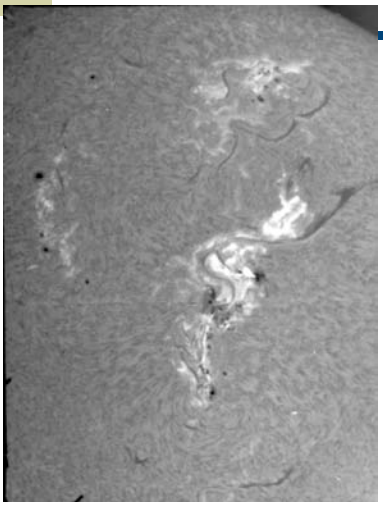
This prototype instrument served as model for a commercially available version produced by the French Ets. SECASI.

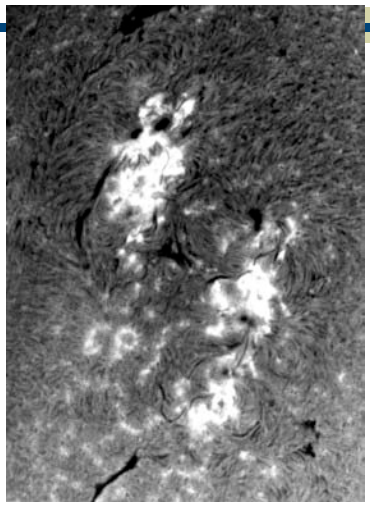
- SECASI heliographs equipped several observatories through the world to operate the IAU coordinated international survey of chromospheric activities.



Later, more elaborated versions of automated solar telescopes were designed, with enlarged images and wavelength scanning.

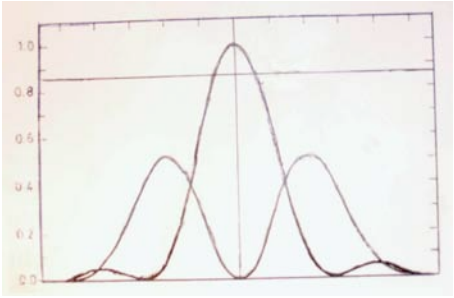
Several thousands of chromospheric active centers were recorded with automated heliographic telescopes, during several solar cycles of 11 years.





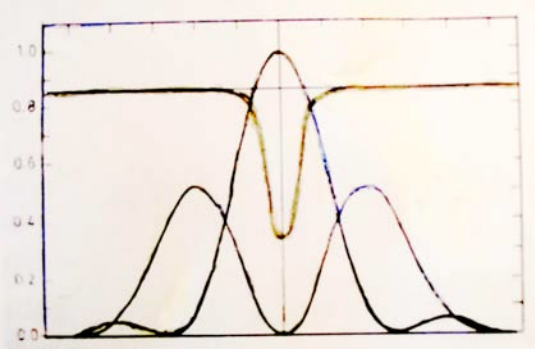
THE PHOTOELECTRIC CORONAMETER

In 1947, Bernard Lyot devised a clever way to made use of his birefringent filter for accurate spectrophotometry. If the last polarizer attached to the thickest plate is turned by 90°, the narrow transmitted band is turned off but replaced by two narrow bands, each of half intensity, both sides of the original band.

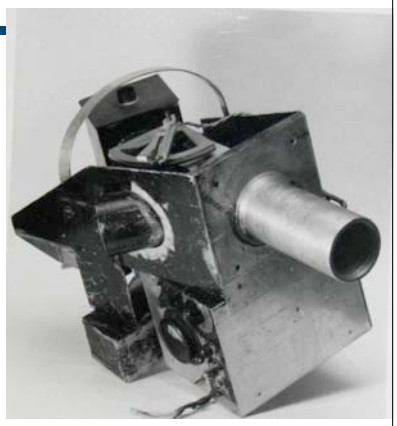


- The transmitted band is centred at a spectral line. For one position the line is transmitted, for the other it is the continuum both side of the line which is transmitted.

The ratio between the two intensities produces a measurement of the line intensity. The method is suitable for very high accuracy measurements.



- In order to shift very quickly from one position to the other and record the fluxes with all the sensibility of the newly available photomultiplier detectors, Lyot designed a new instrument.



The photoelectric polarimeter

was able to detect on faint sources a modulated flux of 0.01%.

The instrument was operational In 1948.

Lyot used his photoelectric polarimeter in conjunction with his birefringent filter, to

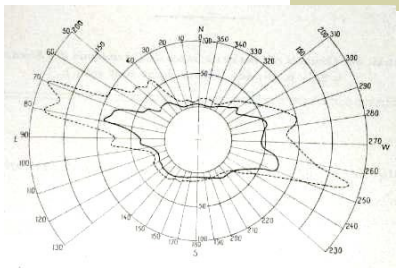
detect the solar corona directly from Meudon,

without coronagraph and without the need to observe from a high mountain.

The PHOTOELECTRIC CORONAMETER was designed in 1950.

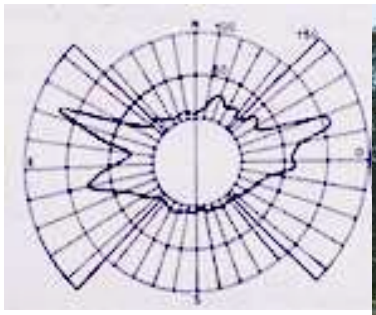
- A refractor telescope of 16 cm diameter, bore sighted with the 1m telescope ef Meudon observatory, was followed by the birefringent filter and then by the photoelectric polarimeter.

Bernard Lyot detected for the first time the solar corona from Meudon observatory with his coronameter on May 6, 1950.



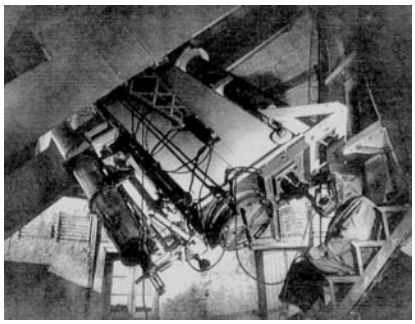
An observation made at Meudon Observatory is compared with measurements taken the same day with the Pic du Midi coronograph.

- After the tragic death of Lyot in 1952, the principle of the coronameter was implemented again by Pierre Charvin at Meudon observatory.

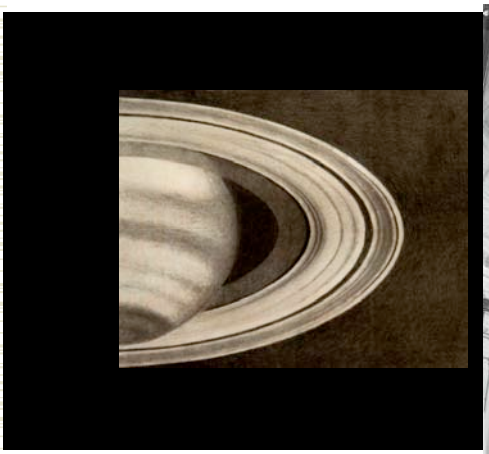


THE HIGH RESOLUTION PLANETARY TELESCOPE

- In 1941, Bernard Lyot decided to initiate a project of planetary exploration with a telescope specially dedicated to high magnification. Benefit was taken of the exceptional stability of the atmosphere at the top of the high altitude mountain Pic du Midi.



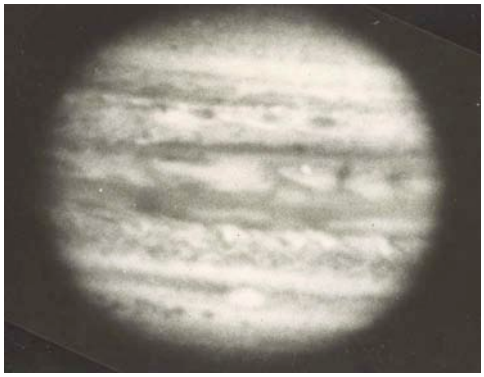
- After tests in 1941 and 1943, the refractor telescope of 60 cm diameter was operational in 1945 and its capacity permitted a magnifications on planets near one thousand.



Lyot observed gaps and channels in the Saturn rings.

- **With Henri Camichel, Lyot performed high resolution photographic images of planets, of unusually sharpness at the time. The technique was still improved later by successors.**

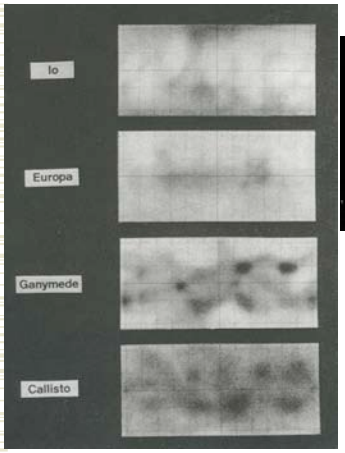
MARS, Apr. 8, 1967. P. Guerin.



JUPITER, Oct. 2, 1975. C. Boyer

- **After Lyot, the telescopic exploration of planets at Pic du Midi was extensively developed, over 30 years, using several other telescopes, until the age and the planetary exploration with spacecrafts.**

SATELLITES OF JUPITER



Io Europa Ganymede Callisto

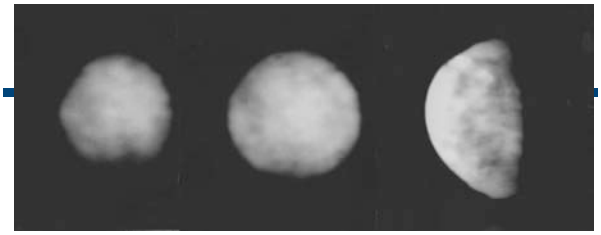
Diameters (micrometry)

Rotation periods (high resolution)

Surface features (high resolution)

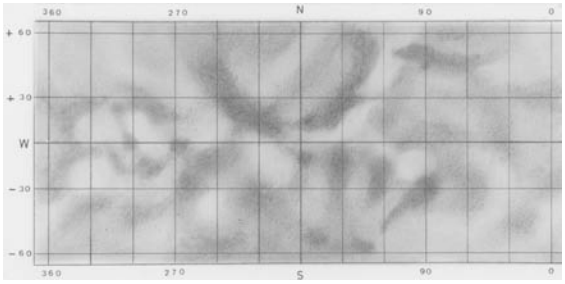
Albedo and colorimetry (photo-polarimetry)

PLANET MERCURY



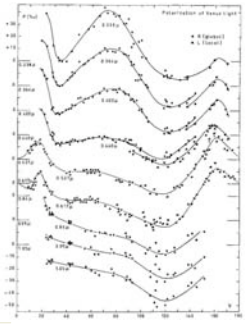
Features at the planetary surface

- **Size and density** (micrometry).
- **Nature of the surface** (polarimetry).
- **Surface features**. (high resolution).
- **Cartography** (photography)
- **Period of rotation** (image processing).



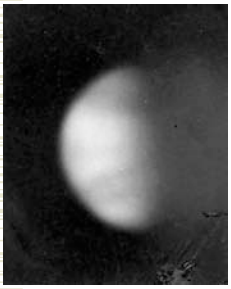
Planisphere of surface features.

PLANET VENUS



- Polarimetry.

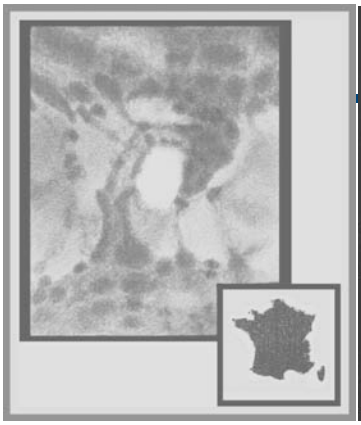
June 20, 1964 **Nov. 6 1943** **Oct. 8, 1943**

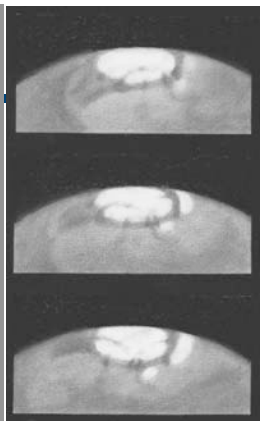


UV. Oct. 15, 1972.

Structure of atmosphere (micrometry).
Nature of clouds (polarimetry)
Dynamics of clouds (UV imagery)
Fast rotation of the atmosphere (UV analysis)

PLANET MARS

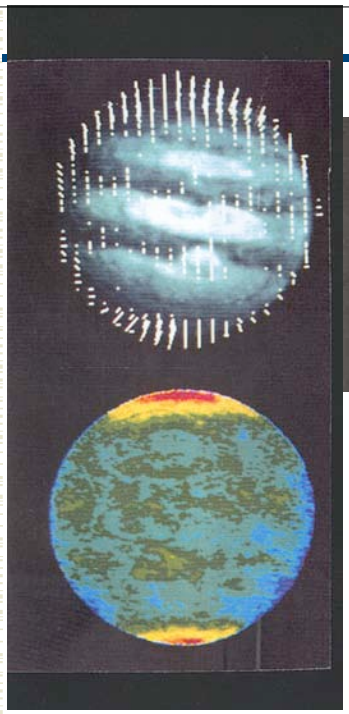




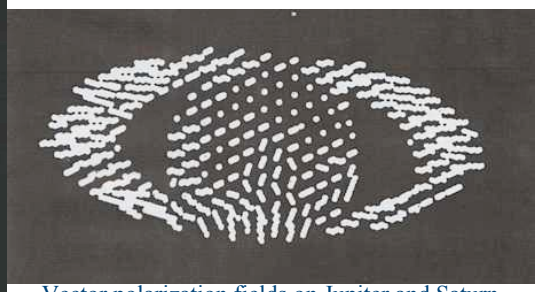
Visual inspection
Photogaphy
Image processing
Micrometry
Polarimetry
Photometry
Spectrometry.

Size and shape
Nature of surface
Seasonal variations

Crystal clouds
Dynamics of dust storms
Search for life.



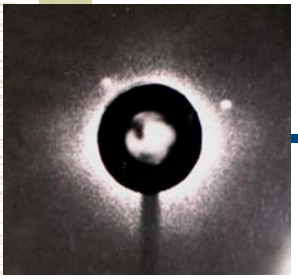
POLARIMETRY

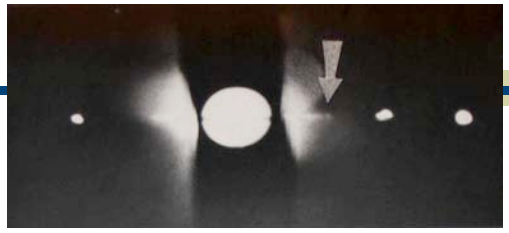


Vector polarization fields on Jupiter,and Saturn

Analysis of the planetary surfaces by polarimetry was extensively practiced at Pic du Midi, using techniques developed by Lyot and then improved, including imaging polarimetry.

FOCAL CORONOGRAPHY

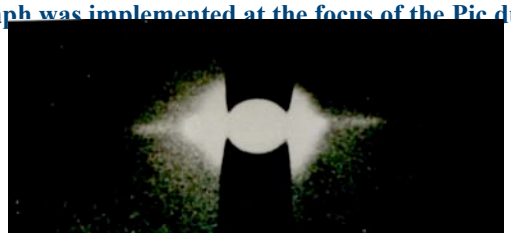




Satellites of Mars
April 11 1982

Discovery of Janus, 10th satellite of Saturn
Decembre 15, 1966

- **The principle of the coronograph was implemented at the focus of the Pic du Midi planetary telescopes.**
- **- Discovery of Janus,**
  the 1th satellite of Saturn.
- **- Ring E around Saturn.**
- **- Planetary satellites**



- **The planetary observation program at Pic du Midi from 1941 to 1975 pre-dated the era of planetary exploration with spacecrafts.**
- **It also pre–viewed what could be the processes of analysis of exo-planets around stars with the future powerful telescopic techniques to come.**


THANK YOU