Charles Boyer and the Rotation of Venus

Adouin Dollfus
Observatoire de Paris, Section d'Astrophysique, 5, place Jules Janssen,
F-92195 Meudon Principal Cedex, France

In August 1957, the magistrate Charles Boyer, who was President of the Court of Appeal at Brazzaville in Africa and an amateur astronomer, began to photograph the planet Venus systematically, using a violet filter and his own personal telescope, 256-mm in diameter, with an optical window. His aim was to study the positions of the dark, changing markings that had been detected in ultraviolet light by Ross at Mount Wilson in 1924. He was collaborating with Henri Camichel at the Pic-du-Midi Observatory, who was simultaneously observing with a 60-cm reflector. Over 68 days' observation, Charles Boyer noted a periodicity of 4 days in the appearance of the markings. Alerted by this, Henri Camichel found the same effect on his series of images. Charles Boyer photographically added together the images on plates obtained at daily, 3-day, 4-day, and 5-day intervals (1). The combination of different images cause the markings to disappear. Only superimposition of 4-day images revealed any detail, the result of periodicity in the planet's appearance.

From new observational campaigns undertaken from Brazzaville in 1959 and 1960, as well as the examination of older photographs taken at the Pic-du-Midi by Audoin Dollfus in 1948 and Henri Camichel in 1953–4, Charles Boyer was able to detect an alternation of central and limb markings that resembled a horizontal "Y", reappearing every 4 days (2). The motion seemed to be from East to West, suggesting that there was a 4-day, retrograde rotation about an axis that was essentially perpendicular to the orbital plane. The intersection of the arms of the Y could be taken as the origin of a system of coordinates. Charles Boyer calculated ephemerides using a period of $96^h 33^m$. Later observations showed a certain variation about this mean period (3, 7).

In order that the appearance of these cloud markings could be followed without the interruptions caused by the planet's rising and setting, Meudon Observatory organised a world-wide campaign for the photographic observation of Venus in the ultraviolet, beginning in 1962, and to which 8 stations contributed. These were located at different terrestrial longitudes in order to obtain images following one another at intervals of a few hours (4, 5). Between 1964 and 1966, Bernard Guinot and Martine Feissel, who examined the Doppler effect by spectroscopic interferometry, independently found a retrograde rotation with a period of -4.3 ± 0.4 days. Yet Charles Boyer's results have continued to meet with great scepticism outside France.

https://doi.org/10.1017/S0252921100092113 Published online by Cambridge University Press

Charles Boyer and Pierre Guérin succeeded, however, using the 105-cm telescope at Pic-du-Midi, in photographing the markings in ultraviolet, in full daylight, and in following their motion from East to West more or less directly, and several times for 6 hours (6).

They were able to draw up a chart of the average appearance of the recurrent features in the cloud layers, and where the horizontal Y is related to a similar feature like the Greek character psi, turned through 90°.

The periodic return of the equatorial Y and psi features again confirms the average period of retrograde rotation of these markings as being almost equal to 4 days (7, 8). This period, which applies at the equator, increases noticeably when the latitude of markings exceeds $\pm 6°$ (8). The velocity of the horizontal displacement is found to be slower, $83\,ms^{-1}$, in the morning before the subsolar point is reached, but to accererate afterwards, reaching $122\,ms^{-1}$ in the afternoon (9, 10).

In 1974, more or less all the photographs of Venus taken in the ultraviolet since the discovery of the UV markings by Ross in 1927 that were available in the world were brought together at the International Astronomical Union's Planetary Photography Centre by Charles Boyer and Audoin Dollfus. These were subjected to systematic analysis (11). For 1972, in particular, the numerous, excellent photographs from the Lowell, New Mexico, and Table Mountain Observatories and, above all, from Pic-du-Midi – especially those obtained by Charles Boyer and Michel Aurière – enabled practically continuous surveillance of the appearance of the clouds over 28 consecutive days. This coverage was shown by 7 charts covering as many consecutive rotations of Venus (11).

In the meantime, the Soviet spaceprobe Venera 8 had landed a capsule on the surface of Venus on 1972 July 22, and VLBI (Very Long Baseline Interferometry) analysis of the signal emited during the parachute descent had enabled V.V. Kerzhanovich to detect a retrograde atmospheric flow of $100\,ms^{-1}$ at a height of 55 km. On its journey to Mercury, the American spaceprobe Mariner 10 flew past Venus on 1974 February 5, carrying on board a telescope specially fitted with an ultraviolet filter, and returned a regular sequence of images during the approach phase. These were reconstructed into the form of a movie film, which immediately showed that the clouds were rotating in the retrograde sense discovered by Charles Boyer at an average velocity of $-110\,ms^{-1}$. The Y and psi cloud features could be seen distinctly.

Profiting from all these results, Jacques Blamont proposed releasing balloons into the atmosphere of Venus, which, carried by the winds, would be able to analyze the atmospheric properties over a long track. This proposal was first studied by Michaël Marov, when it was known as Project EOS, and it finally materialised in 1985 as part of the Soviet Vega mission. On 1985 June 10 and June 14, 2 balloons were released from an entry capsule into the atmosphere of Venus, inflated whilst hanging from a parachute, and stabilized at 50 km altitude. Each flew at this level for nearly 2 days, and covered half of the equatorial circumference of Venus, carried from East to West at $100\,ms^{-1}$ by the atmospheric flow discovered by Charles Boyer.

https://doi.org/10.1017/S0252921100092113 Published online by Cambridge University Press

References

1. Boyer, C. & Camichel, H. (1960), Société Astronomique de France, Commission des Surfaces Planétaires, "Photographic study of Venus in violet and ultraviolet light", [in French], *L'Astronomie*, **74**, 375–381
2. Boyer, C. & Camichel, H. (1961), "Photographic observations of the planet Venus", [in French], *Ann. Astrophys.*, **24**, 531–535
3. Boyer, C. & Camichel, H. (1965), "Photographic study of the rotation of Venus", [in French], *C.R. Acad. Sci. Paris*, **260**, 809–810
4. Boyer, C. (1965), "Study of the rotation of Venus", [in French], *L'Astronomie*, **79**, 223–228
5. Dollfus, A. (1968), "Synthesis on the ultra-violet survey of clouds in Venus' atmosphere", in *The Atmospheres of Venus and Mars*, Gordon and Breach, London, pp. 133–145
6. Boyer, C. & Guérin, P. (1966), "Direct evidence by photography of a retrograde 4-day rotation of Venus", [in French], *C.R. Acad. Sci. Paris*, **263**, 253–255
7. Boyer, C. & Camichel, H. (1967), "Determination of the rotation velocity of markings on Venus", [in French], *C.R. Acad. Sci. Paris*, **264**, 990–992
8. Boyer, C. & Guérin, P. (1969), "Study of the 4-day retrograde rotation of the upper atmospheric layer of Venus", [in French], *Icarus*, **11**, 338–355
9. Boyer, C. & Guérin, P. (1971), "Irregularities in the 4-day rotation of cloud markings in the shape of a Y in the upper atmosphere of Venus, and their correlation with the slow rotation of the surface", [in French], *C.R. Acad. Sci. Paris*, **273**, 154–157
10. Boyer, C. (1973), "The 4-day rotation of the upper atmosphere of Venus", *Planet. Space Sci.*, **21**, 1559–1561
11. Dollfus, A. (1975), "Venus: Evolution of the Upper Atmospheric Clouds", *J. Atmospheric Sci.*, **32**, 1060–1070