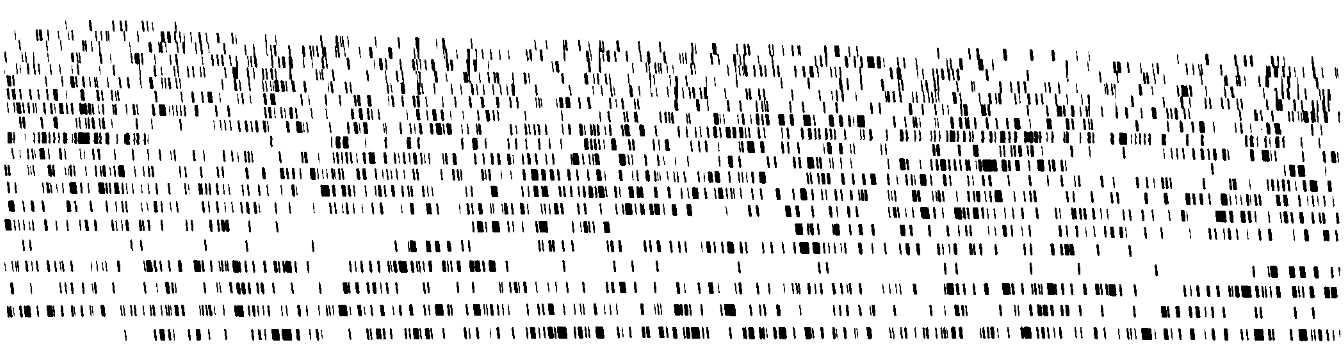


A part of the mask for the CORAVEL instrument, here shown in negative. Each line corresponds to a line in the spectrum of a late-type (cold) star. More than 3,000 lines were drawn by a computer programme operating the ESO S-3000 measuring machine in Geneva in a play-back mode. The mask is enlarged several times in this figure.

The CORAVEL

The measurement of radial velocities, i.e. the velocity in the direction of the line of sight, is of fundamental importance in stellar as well as in galaxy astronomy. Until the 1960s the only possible method was to obtain a spectrum on a photographic plate and then measure the displacement of the spectral lines. These observations were extremely time-consuming for faint objects. With the advent of image-intensifying devices, the observing time was drastically reduced, but so was—unfortunately—the accuracy of the measurement, due to geometric distortions in the image tubes. Now, however, the situation has improved very much indeed, as explains Dr. M. Mayor *of the Geneva Observatory, who, together with several European colleagues, is building a spectrometer to determine stellar* radial *velocities by a* correla*tion method.*

The Marseille and Geneva observatories (A. Baranne, M. Mayor and J. L. Poncet) are working together to build two spectrophotometers for stellar radial velocities. Testing of the first machine has been completed. But before giving the results of these tests it could be useful to review the principles of operation of these "spectrovelocimeters".

In the last ten years, the field of stellar radial velocities has been enriched by a new method whose efficacity and precision for late spectral type stars is exceptional. The development of this method and the proof of its reliability are due to R. Griffin at Cambridge. He has been able to measure the radial velocity of a 14th B-magnitude star to within 1 km/s in only 4 minutes at Palomar!

The Doppler shift measurement is done by means of an optical cross-correlation between the stellar spectrum and a mask located in the focal plane of the spectrograph. This mask is designed to stop photons coming from the stellar continuum and is transparent in the regions of the absorption lines. The spectrum is scanned across the mask and the point of minimum light transmission is located. CORAVEL, which is designed to work at the Cassegrain focus, is a fairly compact apparatus with a collimator focal length of only 60 cm. Nevertheless, its echelle grating which is used between the 43rd and 62nd orders gives a mean dispersion of about 2 Å/mm over the 1500 Å spectral range. The total light transmitted by the mask is measured by a photomultiplier. Rapid scanning at about 4 Hz is used to eliminate atmospheric scintillation effects and the correlation function is built up on-line by integration in the memory of the HP 2100 computer. The zero point of the radial velocities is determined by means of a hollow cathode iron lamp which illuminates the entry slit at the beginning and end of each measurement. The reduction of the Earth's motion is immediately done at the end of the measurement.

The mask used in CORAVEL is derived from the spectrum of Arcturus and consists of about 3,000 holes distributed over the 20 orders of the echelle grating. The useful zone of the mask is approximatively 13 x 70 mm. The calibration of the focal surface and the drawing of the work was done using the OPTRONICS two-coordinate microphotometer of the ESO Sky Atlas Laboratory. A small modification of the microphotometer allows it to be used in play-back mode to make a negative on a high-resolution photographic plate. A negative copy of this plate gives us the mask which in fact is a glass plate coated with chrome.

Measurements of the sky light from the laboratory permit a partial test of the mask. The correlation dip for the Sun is characterized by a 15 km/s width at half depth. The daily variation of the solar radial velocity (0.3 km/s at Geneva) is easily measured with a scatter of $\pm$ 0.1 km/s for the individual measurements. Tests on stars other than the Sun are planned during the next few weeks and will be the subject of another report.

An observation period at La Silla is planned after some months of observing in the northern hemisphere.

Of Apollos and Trojans

It is often seen in science that more is learned from abnormal ("pathological") cases than from the normal ones. This is certainly true in astronomy too.

The title of this note should not confuse the reader. We do not attempt to discuss the mentality or health of ancient Greek gods and warriors, but rather to summarize some new information pertaining to these two "families" of minor planets which has recently become available from observations with ESO telescopes. They represent extremes in the asteroid world: the Apollo planets are those which come closest to the Earth; the Trojans are more distant than any other known minor planets.

1976 WA

Comparatively few Apollo asteroids are known to date. The most famous, (1566) Icarus, comes within 28 million kilometres from the Sun, in a very elongated orbit that also carries it across the Earth's orbit. The interest in these rare objects has recently increased considerably after the discovery of not less than four new Apollos within a span of only 11 months. Two were discovered late in 1975 at the Palomar Observatory (1976 AA and 1976 YA), the third in October 1976, also at Palomar (1976 UA, cf. THE MESSENGER No. 7, p. 5) and the fourth, 1976 WA, was the first one found by the ESO Schmidt telescope for which a reliable orbit was also established.

1976 WA is another by-product of the ESO (B) Survey of the Southern Sky. It was discovered by Dr. H.-E. Schuster on a 60-min plate taken for this survey on November 19, 1976 as an unusually long trail. Further plates were obtained on the following nights, and after accurate positions had been measured, Dr. B. Marsden was able to calculate the orbit on December 6. Observations by Dr. E. Roemer with the 229-cm telescope of the Steward Observatory, situated at Kitt Peak, improved the orbit, and it was found that this new Apollo-type planet passed only 20 million kilometres from the Earth on October 3.

From its apparent magnitude, the size of 1976 WA is estimated to be 1–1.5 km. Its orbit is extremely elongated (the fourth most elongated known!) and it moves between 124 million and 598 million kilometres from the Sun, i.e. going well beyond the orbit of Mars while almost touching that of Venus.

1976 UQ and 1976 UW

Some weeks before the discovery of 1976 WA, a small observational programme was carried out with the ESO Schmidt telescope, the aim of which was to search systematically for new Apollo asteroids. This programme was proposed by Dr. L. Kohoutek of the Hamburg Observatory, who may be more known for the comets he has discovered than for the many minor planets he also has to his credit.

Dr. Kohoutek reasoned that, in order to increase the chance of discovering Apollo objects in the vicinity of the Earth's orbit, one must look along this orbit. Other considerations show that the chances are even better if one looks slightly inside the Earth's orbit, at about 80° elongation from the Sun. This is shown in the figure.

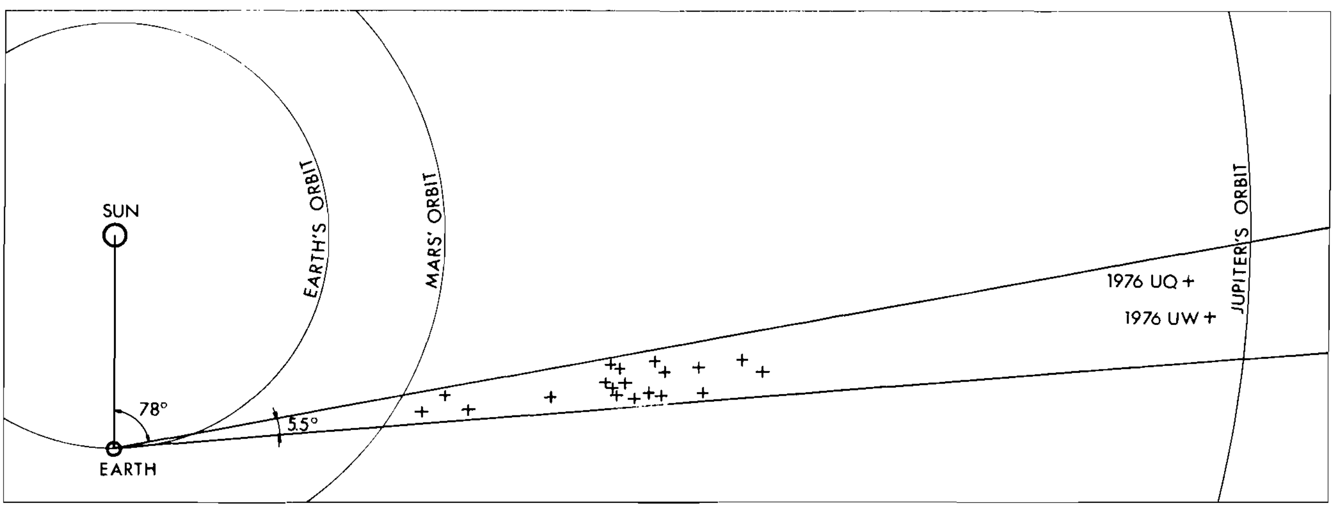
Schmidt plates were taken in this direction towards the end of October by Dr. R. M. West, assisted by Guido Pizarro. The weather could have been better, but six plates were obtained during a period of ten nights. The plates were "blinked" (intercompared in a special machine that allows the operator to see first one plate and then another, so that the image of any moving object will appear to jump back and forth when switching from one plate to the other) and the positions of twenty-seven minor planets that were seen on the plates could thereafter be measured on the ESO S-3000 measuring machine in Geneva.

This material was transmitted to Dr. Marsden at the Smithsonian Observatory in Cambridge on November 12, and by hard work he was able to calculate preliminary orbits for all 27 objects within a few days. Checking with already known asteroids, he found that two of the planets were identical with (1069) Planckia and (1881) Shao, but that the other twenty-five were all new discoveries.

With a time span of only ten days, these orbits could of course not be very precise, and some were somewhat indeterminate. But one conclusion could be drawn: there were *no* new Apollo-type asteroids among the twenty-five! However, to some surprise, two of the new asteroids turned out to be new Trojans, at distances of close to 750 million kilometres from the Earth. A strange paradox: you look for the close and you find the distant.

On the basis of Dr. Marsden's orbits, the ephemerides (expected positions) were computed and the most interesting asteroids could be refound and observed until the end of January 1977. It has now been confirmed that none are Apollos, and that 1976 UQ and 1976 UW may definitely be added to the small list of minor planets, carrying the names of hero-warriors and other persons involved in the siege of Troy. It even turns out that 1976 UQ has the highest known orbital inclination among Trojans, 39°, which also happens to be the fifth highest inclination among all (2,000 or so) minor planets with well-known orbits.

Like the other Trojans, the two new planets are bound to follow orbits that are determined by the combined gravitational field of the Sun and Jupiter. The orbital periods are close to that of Jupiter, approximately 12 years.



Geometry of the ESO "Apollo" programme, end of October. The field of the Schmidt plates has been indicated (5°5) as well as the positions of twenty-one new minor planets for which the distance from the Earth could be computed. The two new Trojan planets, 1976 UQ and 1976 UW, are close to the orbit of Jupiter. Note how the asteroids cluster at particular distances.