Astronomers measure an elusive 'Rossiter-McLaughlin effect' during the last Venus Transit

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A team of Italian astronomers performed a very difficult measurement for which it was necessary to use the most advanced instrumentation in combination with an unusual technique, so as to involve even the Moon as a natural astronomical mirror. The challenge was the observation of effect occurred during the transit of Venus across the Sun on June 6th, dubbed "Rossiter-McLaughlin effect". This is a phenomenon that occurs when a celestial body passes in front of a star, hiding a part of its rotating surface and that produces a temporary distortion in the profiles of the spectral lines of light coming from the eclipsed star. Astronomers led by Paolo Molaro, from INAF Astronomical Observatory of Trieste succeeded in this ambitious task, observing and measurirng the magnitude of this tiny effect. Their findings are published online today in a paper of the journal *Monthly Notices of the Royal Astronomical Society*.

The Rossiter-McLaughlin effect has already been observed in systems composed of two stars that eclipse each other, but it becomes more and more difficult to observe when the celestial body is the size of a planet, and moreover not so great as Jupiter but rather similar in size to the Earth, just as it is during the transit of Venus. Measuring the extent of this weak effect on the light from other planetary systems through telescopes of the next generation such as E-ELT (the European Extremely Large Telescope) will be a useful tool for the search and study of exoplanets. Astronomers will be able to learn important orbital

parameters in these systems and thus improve our understanding of the history of their formation.

"Critical to the success of this mission was the use of the HARPS spectrograph at ESO that now, along with his 'twin brother' installed at the Telescopio Nazionale Galileo (TNG) operated by INAF on Canary Islands, represents the state of the art for measuring radial velocities of celestial objects and the best hunter of planetary systems around other stars. The measured magnitude of the effect is comparable to being able to track the speed of a person walking at a slow pace at a distance of 150 million kilometers, the space that separates us from the Sun. Nowadays there is no other instrument capable of recording so tiny changes, especially if you only have a few hours to measure them" said Lorenzo Monaco, an Italian astronomer working at ESO.

But the mere use of HARPS would not be sufficient to achieve this result. The observations of the integrated light of the sun at high resolution are in fact extremely difficult to conduct and to overcome this problem, astronomers pointed their instruments to the Moon to capture the sunlight reflected from it. For this reason, the transit was observed by astronomers in Chile when in fact it would be impossible to do so, since in that region of the world it was night. This unusual strategy has imposed special calculations to achieve the desired results. "The transit of Venus seen from the Moon has a slightly different schedule than what has been observed on Earth," said Simone Zaggia from INAF Astronomical Observatory of Padua, who participated in the mission. "The Moon was in fact 8 degrees ahead of the Earth and Venus reaches alignment with the Sun and the Moon about two hours later. The transit was also slightly longer than that observed on Earth because the Moon was above the plane of rotation of the Earth around the Sun".

Observations show that the partial eclipse on the solar disc produced by the transit of Venus has generated a modulation in the radial velocity of

the Sun of less than one meter per second, which is just 3 km/h. "The agreement with the theoretical models is around a few centimetres per second and is an amazing result ever reached before" says Mauro Barbieri, from University of Padua, who is also a member of the team. "Among other things, this change in velocity is comparable with that due to the natural expansion and contraction of our star. However, our observations have allowed us to clearly see the Rossiter-McLaughlin effect during transit".

The results obtained from these observations - the only ones with purely scientific purposes that have been carried out on the Earth during the last transit of Venus - will be of great help to astronomers, who in the next decade will be able measure this phenomenon in extrasolar systems, unleashing the full potential of new generation of telescopes such as the E-ELT. "This measurement - says Paolo Molaro - foretells the sensational results that in a few years will be able to get thanks to the advent of the 40-meter class telescopes equipped with high-resolution spectrographs. This mammoth astronomical instruments will open for sure a new horizon in the study of orbital properties of other Earth-like planets that are found around other stars in our galaxy".

Provided by INAF Astronomical Observatory