

Study of mutual occultation phenomena of the Galilean satellites at radio wavelengths

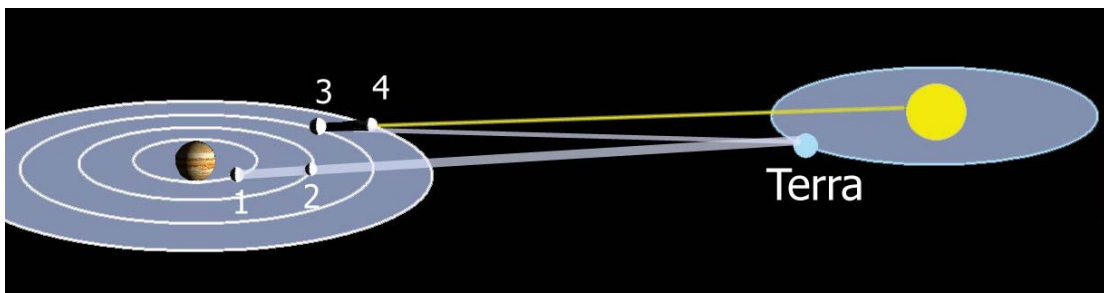
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Abstract: We present preliminary results for our study of mutual phenomena of the Galilean satellites performed at radio wavelengths with the Medicina and Noto antennas of the Istituto di Radioastronomia – INAF, and with the Effelsberg 100-m radio telescope of the Max-Planck-Institute for Radioastronomy, Bonn. Measurements of the radio flux variation occurred during the mutual occultations of Io by Europa and Ganymede were carried out during the PHEMU09 campaign at K- and Q-band. Flux density variations observed at radio wavelengths are consistent with the typical optical patterns measured when partial occultations occur.



Twice every 11.8 years Jupiter transits the nodes of its orbit. Since the inclination of the orbital planes of Galilean satellites with respect to the planet's equatorial plane is very small, for a few months during these passages, the satellites either occult or eclipse each other, depending on whether they are collinear with the Earth or with the Sun, respectively. These events are referred to as mutual phenomena (PHEMU). Their observation can be used, for instance, to derive corrections of the orbital parameters or to study the surface properties of the involved Jovian satellites.

We have studied PHEMU of the Galilean satellites at radio wavelengths by using the radio occultation technique. This method requires to point the occulted satellite (Io in this case) and to track it while it is occulted by the other one (Europa or Ganymede).

Observations were performed with the Noto and Medicina 32-m antennas of the Italian Istituto di Radioastronomia and with the 100-m radiotelescope of the Max-Planck-Institute for Radioastronomy, Bonn.

Observational frequencies were 43 GHz (Nt), 22 GHz (Mc) as well as 10 and 32 GHz (Eb). At Medicina and Noto data were recorded with the Mark IV backend for VLBI. On this occasion the newly installed Medicina K-band receiver was tested coupled with the new Enhanced Single-dish Control System (ESCS). At Effelsberg data were taken with the Digital Backend used for continuum observations.

Data acquired by the Italian antennas were post processed with the Advanced Software Tools for Radio Astronomy (ASTRA) developed by our group. Data collected at Effelsberg were analyzed with the CONT2 subpackage of the Toolbox package for the analysis of single-dish radio observations.



From the top: the Noto, Medicina and Effelsberg radiotelescopes

- OBSERVED EVENTS -

DATE (TE)	MAXIMUM PHENOMENA	MAXIMUM MAGNITUDE	DUR	DIST. SAT.	DIST. IMPACT	ELEV.
YYYY MM DD	H M S		S	(RS)	(")	deg deg
2009 6 10	2 OCC 1 P	5 11 43.	0.152	187	2.2	0.587 +29 +35
2009 6 17	2 OCC 1 P	7 17 46.	0.064	145	2.0	0.799 +12 +14
2009 10 8	3 OCC 1 P	17 51 6.	0.030	184	3.3	1.189 +25 +33
2009 10 15	2 OCC 1 A	17 21 44.	0.426	221	1.5	0.036 +24 +33
2009 10 15	3 OCC 1 P	20 30 33.	0.071	254	3.9	1.008 +25 +30
2009 10 22	2 OCC 1 P	19 30 19.	0.426	223	1.7	0.079 +27 +33
2009 11 16	2 OCC 1 A	15 14 29.	0.426	234	2.6	0.015 +25 +33
2009 11 23	2 OCC 1 A	17 30 54.	0.426	238	2.8	0.055 +28 +34
2009 11 28	3 OCC 1 P	13 46 42.	0.025	254	5.4	1.036 +20 +28
2009 11 30	2 OCC 1 P	19 48 53.	0.388	240	3.1	0.142 +12 +14
2009 12 11	2 OCC 1 P	11 18 38.	0.281	237	3.5	0.298 +07 +13
2009 12 18	2 OCC 1 P	13 40 16.	0.201	227	3.7	0.413 +27 +35
2009 12 25	2 OCC 1 P	16 3 14.	0.123	206	4.0	0.533 +28 +35
2010 1 1	2 OCC 1 P	18 27 34.	0.054	169	4.2	0.655 +10 +11
2010 3 21	2 OCC 1 P	10 8 35.	0.397	1882	1.4	0.112 +38 +46
2010 3 28	2 OCC 1 P	9 1 15.	0.400	1980	1.3	0.109 +32 +31

List of observed events. In column three, n.1 indicates the Io satellite, n. 2 and 3 indicate the Europa and Ganymede satellites, respectively

Top: astrometric maps of the 2OCC1 PHEMU events occurred on June 10th (on the left) and December 18th (on the right) 2009. The maps were derived from JPL ephemeris values of the Jovian satellites. Blue and orange circles indicate side and central positions respectively of Io during the occultation. Red circles indicate the Europa position during the maximum of the occultation. **Middle:** numerical model of the occultation curves computed and displayed by a customized software developed by our team. The software is able to simulate the flux density variation of any mutual event, by setting key parameters such as radii of the satellites, their mean flux densities, impact parameter and time duration. **Bottom:** flux density variation measured during occultations. Signals are total power, already on-off corrected and calibrated. Blue curves indicate the flux density measured at 22 GHz by the Medicina antenna. Signal integrations were performed over the entire available bandwidth. Green curves indicate the expected flux density variation according to the numerical model. Results are in good agreement with the expected values. The observational campaign is still ongoing, however results from annular occultation measurements clearly show the necessity of further studies.

