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Astronomy

Electropolarimetric Study of Jupiter's Galilean Satellites

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ABSTRACT. The polarization properties of light, reflected from Jupiter's satellites, are studied. Maximum difference is noticeable between polarization degrees of light, reflected from the satellites' front and rear hemispheres. For the satellites located relatively close to Jupiter (Io, Europe, Ganymede), the magnitude of polarization degree of light, reflected from the front hemisphere, is comparatively less than the magnitude of polarization degree of light, reflected from the rear hemisphere, and *vice versa* for satellite Callisto. A hypothesis is presented in order to explain the mentioned differences. *© 2012 Bull. Georg. Natl. Acad. Sci.*

Key words: *Galilean satellites, polarization degree, front and rear hemispheres.*

It is possible to name only several scientific works [1-3] in which polarization properties of Jupiter's Galilean satellites are studied .

Proceeding from the above stated I have set my mind since 1981 on the investigation of polarization properties of Jupiter's Galilean satellites in the alpha angle of each phase and in ten different areas of the visible spectrum . The observed material was obtained at the Abastumani Astrophysical Observatory, Georgian Academy of Sciences on both 40-cm refractor and 125-cm reflector, to which polarimeter ASEP-78 was attached during observations.

Due to the fact that consideration of the effect of Jupiter's surrounding background is rather complicated, we did not conduct Jupiter's observations from limb along 2-3 radii vision ray. It should also be mentioned here that a mean square error of one measurement during observation without filter does not exceed 0.05%. The observational method is described in detail in [4].

Taking all the above stated into account, a relatively reliable observation of Jupiter's Galilean satellites is possible when they are within the following orbital intervals:

Io	]30°; 150°[and]210°; 330°[
Europe	]19°; 161°[and [119°; 341°[
Ganymede	]12°; 168°[and]192°; 348°[
Callisto	]7°; 173°[and [187°; 353°[

In general the magnitude of polarization degree of light, reflected from a satellite's surface, must vary depending on the α-phase angle, satellite orbital longitude L, wave length λ and observation period t, or $P = P(\alpha, L, \lambda, t)$.

Observations. In the present work polarization properties of light, reflected from Jupiter's satellites, are studied. Maximum difference is noticeable between the polarization degrees of light, reflected from satellites' front and rear hemispheres. For satellites located relatively close to Jupiter (Io, Europe, Ganymede), the magnitude of polarization degree of light, reflected from front hemisphere, is comparatively less than the magnitude of polarization degree of light reflected from the rear hemisphere, and vice versa for satellite Callisto. In the present paper an acceptable hypothesis is proposed in order to explain the mentioned differences.

Based on the processing of obtained materials the author deduces that:

1. The magnitude of polarization degree of light reflected from the front side ($L \approx 90^o$) of satellite Io during observations without filter is in absolute magnitude by 0.15 – 0.20% less than the magnitude of polarization degree of light, reflected from the rear side ($L \approx 270^o$) when phase angle $\alpha \approx 5^o$, while the magnitude of polarization degree of light reflected from satellite Io's rear hemisphere is equal to $P(\alpha) = P(5^o) = -0.38\%$.

2. The magnitude of polarization degree of light, reflected from satellite Europe's front side during observations without filter is in absolute magnitude by 0.12% less than the magnitude of polarization degree of light, reflected from the rear side, when phase angle $\alpha \approx 3^o.5$, and the magnitude of polarization degree of light, reflected from satellite Europe's rear hemisphere, is equal to $P(\alpha) = P(3^o.5) = -0.25\%$.

The magnitude of polarization degree of light reflected from satellite Ganymede's front side during observations without filter in absolute magnitude is by 0.15 – 0.18% less than the magnitude of polarization degree of light, reflected from the rear, when phase angle $\alpha \approx 5^o$, while the magnitude of polarization degree of light, reflected from satellite Ganymede's rear hemisphere, constitutes $P(\alpha) = P(5^o) = -0.40\%$.

3. The magnitude of polarization degree of light reflected from satellite Callisto's front side during observations without filter in absolute magnitude is by 0.65% more than the magnitude of polarization degree of light reflected from the rear side, and constitutes 0.35%.

Analysis. It is evident that the magnitude of polarization degree of light, reflected from the front hemisphere of the first three satellites (Io, Europe, Ganymede), is less that the magnitude of polarization degree of light, reflected from the rear hemisphere, while in the case of satellite Callisto it is vice versa. One of the possible hypotheses for explaining this phenomenon is the following: as is known there is a shower of a multitude of meteorites, moving both on circular and elliptic orbits. Showers of meteors, moving on elliptic orbits in the direction, coinciding with the satellites' direction, must be the reason of the above mentioned exposed difference. These showers are falling asymmetrically upon the satellites' front and rear hemispheres.

In order to facilitate our calculations let us review meteor showers, the pericenter of which is $\sim 6R_J$ close to the satellites' (specifically Io's) orbit, located near the planet, and the apocenter $\approx 26R_J$ close to satellite Callisto's orbit.

In such case, as is well-known from celestial mechanics, the velocity of a body's movement in pericenter and apocenter is calculated using the following formulae:

$V^2 = V^2_c\,(1+e)/(1-e)$ (in pericenter), $V^2 = V^2_c \times (1-e)/(1+e)$ (in apocenter), where V_c is the main velocity of an object moving on orbit, e is the orbit's excentricity.

On the one hand, it may be easily obtained that the velocity of meteoric bodies, having the above mentioned properties, will equal V = 22.50 km/sec. in pericenter and V = 5.04 km/sec in apocenter.

On the other hand, optimum velocities of Galilean satellites moving on circular orbits, are: for Io 16.94 km/sec., Europa 13.43 km/sec., Ganymede 10.63 km/sec. and Callisto 8.01 km/sec.

Evidently, the indicated meteoric bodies are falling upon Io from the rear side ($V_{Flow}>V_{Io}$), while in the case of Gallisto ($V_{Cal} > V_{Flow}$) we have the opposite picture. Callisto is gathering on and overtaking meteor showers, which bombard it from the front side due to the fact that the majority of meteoric bodies are dark (have less albedo and a high polarization degree). Consequently the light reflected from the satellite's indicated side corresponds to the higher polarization degree [4]. As the mentioned effect lasts for billions of years, the satellite's front and rear sides differ from each other.

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იუპიტერის გალილეისეული თანამგზავრების ელექტროპოლარიმეტრიული შესწავლა

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