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POLARIMETRIC INVESTIGATIONS OF THE MOON AND PLANETS AT ABASTUMANI ASTROPHYSICAL OBSERVATORY

R. A. Chigladze [a,b]

[a] *Shamakhy Astrophysical Observatory named after Nasireddin Tusi of the Azerbaijan National Academy of Sciences*

[b] *Samtskhe-Javakheti State University*

The paper gives a brief description of the instruments of polarimetric investigations of the Moon and planets at Abastumani observatory and presents some results of the long-standing polarization observations of the Moon, Jupiter, Saturn and Jupiter's Galilean Satellites at the observatory.

Keywords: Moon, Jupiter, Saturn, Jupiter's Galilean Satellites, Polarization.

1. INTRODUCTION

In the 1950s, the scientists at Abastumani Astrophysical Observatory started regular electro-polarimetric observations of the Moon under the leadership of Professor Victor Dzhapiashvili. Later, the studies were joined first, by Leonid Ksanfomaliti and then, by Otar Kvaratskhelia.

As a result of these works, the world first multi-tone color Moon atlas was published under the authorship of V. Dzhapiashvili and A. Korol, which was awarded with the Bredikhin State Prize.

Today, the polarization properties of over 190 Moon formations are studied (O. Kvaratskhelia). Highly accurate electro-polarimetric measurements show that the changes in the area of the Moon crater Aristarchus are still ongoing in our epoch [1].

On the basis of the observational data obtained at Abastumani Astrophysical Observatory, the distribution of the negative polarization minima (P_{min}) on the lunar surface is studied. It is found that in the integral light (P_{min}) varies within 0.60% - 1.37% from object. The result obtained is a new one in polarimetric investigations of the lunar surface [2] .

In 2019, a Multiparameter Atlas of the Moon dedicated to the blessed memory of Victor Dzhapiashvili was published. The authors of the atlas are Victor Dzhapiashvili's disciples:

O. Kvaratskhelia, R. Chighladze, G. Kimeridze, R. Ivanidze and Sh. Gigolashvili [3].

Of the polarimetric parameters, the correlations between the main phase-polarization P(α) and spectrum-polarization P(λ) parameters and their associations with other parameters of the light reflected from the Moon surface are studied.

Our goal is to identify the typical regions by considering the mentioned parameters and regions similar to the landing regions of "Apollo" and "Luna" series spacecrafts and evaluate their distribution on the Moon surface. The publication of the multiparameter (P_{min}, P_{max}, Color Index, Albedo-In the red and blue areas) atlas of the Moon is dedicated to these issues.

In 1964, the scientists at Abastumani Astrophysical Observatory started to study the polarization properties of the Jupiter (O. Bolkvadze), and the study of the Saturn started in 1972 (L. Sigua).

The distribution of polarization on the visible discs of Jupiter and Saturn is studied in different wavelengths [4].

While in1981, the scientists initiated a polarimetric study of Jupiter's Galilean Satellites (R. Chighladze). **P** (Linear polarization) depending on α-phase angle, **L** - orbital longitude, λ - wave length and t - observation period, or **P** = **P** (α, **L**, λ, **t**), [5].

2. THE MAIN RESULTS OF OBSERVATIONS (FOR THE MOON)

When Confidence Probability is 0.98

Mare Imbrium (North from Autolycus) similar to Apollo 16 landing area Bessel – Picard

When Confidence Probability is 0.97 Bessel – Picard – Hooke Mare Imbrium (North from Autolycus) - Apollo 16 landing area

When Confidence Probability is 0.96

Bessel – Picard – Hooke - Mare Fecunditatis

Aristillus - Apollo 17 landing area

Bullialdus – Cleomedes- Mare Imbrium (North from Autolycus) - Apollo 16 landing area Mare Nectaris –Timocharis

And so on ... **Based on laboratory measurements:**

1. A conclusion is drawn that Pmin can be used as indicator of plutonic deposits. Regarding this, their highest content is fixed in: Crater North from Manilius, Lehmann, Crater North from Mare Serenitatis.

And their lowest content is fixed in: Tycho, Proclus, Aristarchus.

2. A conclusion is drawn that Pmax can be used as indicator of $(FeO-TiO_2)$. Regarding this, their highest content is fixed in: Mare Nectaris, Dzhapiashvili, Mare Crisium.

And their lowest content is fixed in: Proclus, Tycho, Catharina.

3. A conclusion is drawn that Color index can be used as indicator of (MgO – TiO2) Regarding this, their highest content is fixed in: Crater East from Piccolomini,Plato. Crater North from Plato.

And their lowest content is fixed in: Plinius, Flamsteed, Mare Tranquillitatis.

4. A conclusion is drawn that Albedo can be used as indicator of (SiO_2 - Al_2O_3).

Regarding this, their highest content is fixed in: Crater North-West from Tycho, Anaxagoras, Crater South from Deslandres.

And their lowest content is fixed in: Mare Tranquillitatis, Oceanus Procellarum, Luna 16 landing area.

3. THE MAIN RESULTS OF OBSERVATIONS (FOR THE JUPITER'S GALILEAN SATELLITES)

1. The magnitude of polarization degree of light reflected from the front side of Io during magnitude is by 0.20% less than the magnitude of polarization degree of light reflected from the rear side.

2. The magnitude of polarization degree of light reflected from Europe's front side during Magnitude is by 0.11% less than the magnitude of polarization degree of light reflected from the rear side.

3. The magnitude of polarization degree of light reflected from Ganymede's front side during magnitude is by 0.18% less than the magnitude of polarization degree of light reflected from the rear side.

4. The magnitude of polarization degree of light reflected from satellite Callisto's front side during magnitude is by 0.65% more than the magnitude of polarization degree of light reflected from the rear side.

4. ANALYSIS

It is evident that the magnitude of polarization degree of light reflected from the front hemisphere of the first three satellites (Io, Europa, Ganymede) is less than 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 it 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 ~6RJ close to the satellites' (specifically Io's) orbit, located near the planet, and the apocenter ≈ 26RJ close to satellite Callisto's orbit.

In such case, as it is well-known from celestial mechanics, velocity of a body's movement in perocenter and apocenter is calculated using the following formulae: $V^2 = V^2c(1+e)/(1-e)$ (in pericenter), $V^2 = V^2c(1-e)/(1+e)$ (in apocenter), where Vc is main velocity of an object, moving on orbit, and e - 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 an 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).

We have a similar case for Saturn's moons Dione and Iapetus. In case of Dione, the speed is 10 km/sec, and the speed of Japet is 3 km/sec. Meteor speed flow rates both in the pericenter and in the apocenter are 19 km/sec and 2 km/sec.

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