STUDY OF EFFECTS OF LUNAR TIDAL WAVE PASSAGE IN UPPER ATMOSPHERE OF EARTH ACCORDING TO MONITORING DATA AT RADIO TELESCOPE «URAN-4» RI NANU

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ABSTRACT. The paper examines data on the effects of the lunar tidal wave in the Earth's upper atmosphere on the observed flux of radio sources. Monitoring of the fluxes of powerful galactic and extragalactic radio sources is carried out at the URAN-4 radio telescope of the Odessa Observatory of the Institute of Radio Astronomy of the NAS of Ukraine since 1987 till now. The monitoring program includes radio galaxies 3C274, 3C405 and supernova remnants 3C144, 3C461. Changes of fluxes of radiation sources at decimeter waves are determined by the condition of an ionosphere resulted due to space weather variation and tidal events. When radio sources are observed through a tidal wave, a "plasma lens" effect is realized in the ionosphere. Depending on the position of the radio source relative to the tidal wave, the radiation wave front is sought. As a result, various effects are realized: strong focusing, intense flickering or "blurred" recording of the radio source. According to the data of radiation monitoring of powerful radio sources, the dimensions and structure of the tidal wave zone in the upper atmosphere producing the effect of "plasma lensing" have been determined. The total size of this zone according to observations on frequent 20 and 25 MHz is on the order of 30-60 angular degrees in right ascension and declination.

Keywords: atmospheric lunar tides, upper atmosphere, radio sources.

1. Introduction

Tidal phenomena in the Earth's atmosphere arise from the gravitational forces of the Moon and the Sun (gravitational tides) and from thermal heating by the Sun (thermal tides). Apart from the difference between the physical nature of gravitational and thermal tides, they have different periodicity. Gravitational tides have a half-day period and form two tidal waves - direct and reverse. Thermal tides have a daily period and are realized in the area of the terminator.

Data from radio astronomy observations on the «URAN-4» radio telescope are the most effective method of investigating tidal waves occurring in the ionosphere. Since 1987 at the URAN-4 radio telescope the program of monitoring powerful galactic and out of galactic sources is carried out. The monitoring program includes radio galaxies 3C274, 3C405 and supernova remnants 3C144, 3C461. Observations of these radio sources provide uniform 24-hour coverage over time and allow recording of the state of the ionosphere and the processes taking place in it by the given changes in the fluxes of radio sources and their flickering. Observations were conducted in analog recording mode, since 1997 in digital.
2. Abnormal types of radio source records

The work deals with the occurrence of a wave based on the monitoring of radio sources in the digital recording mode, for the period 1998-2004. Radio source records were chosen as the data under study when they passed near the Moon. These data were characterized by three types of records: presence of strong flickering of radio sources, strong compression or complete breakdown of recording of diagrams of direction of radio telescope. All these effects can be caused by the different race position of space radio sources relative to the maximum tidal wave in the ionosphere, which acts like a “plasma” lens, distorting the front of the wave coming from the radio source. For an example of this type of record, refer to Fig. 1-2.

The recorded abnormal records coincided with time of the close arrangement of the Moon and sources on right ascension (Fig. 3-5). During periods when observations were conducted 24 hours a day, the effects of a direct and reverse tidal wave were noted.

Detection of similar effects at radio telescope "УРАН-4" in decameter range is related to value of angular resolution of radio telescope able to register distortion of wave front of radio source radiation under influence of tidal wave in ionosphere. Abnormal records in the presence of focusing, defocusing, and strong flickering phenomena can be interpreted as the effect of developing a "plasma lens" in the Earth’s ionosphere by the formed lunar tidal wave. Applying this interpretation and taking into account the spatial realization of abnormal types of records, it is possible to estimate the dimensions of the lunar tidal wave in the ionosphere, which was in the range of 30-60 angular degrees at right ascension.

The use of the radio telescope "УРАН-4" having a knife pattern, a decameter range of working frequencies and the possibility of long-term tracking of the space radio source demonstrated the possibility to implement a radio astronomy method of observing tidal phenomena in the upper atmosphere of the Earth by the method of transmitting the region of tidal disturbances in the ionosphere.

![Figure 1: Sample 3C405 source record – August 25, 1998 (20-25 MHz)](image1)

![Figure 2: Sample 3C144 source record - April 22, 1988 (25MHz A -80m)](image2)

![Figure 3: The position of abnormal radio 3C274 records varies depending on the distance between the Moon and the radio source by right ascension (1998-2004)](image3)

![Figure 4: The position of abnormal radio 3C405 records varies depending on the distance between the Moon and the radio source by right ascension (1998-2004)](image4)

![Figure 5: The position of abnormal radio 3C461 records varies depending on the distance between the Moon and the radio source by right ascension (1998-2004)](image5)
Due to the large number of observations of the approach of radio sources to the Moon, further detailed study of the effects of the "plasma lens" in the ionosphere as a result of the magnitude of tidal disturbance is possible. An important factor is the consideration of the position of the radio source relative to the maximum of the tidal wave, which will be carried out in next works.

3. Conclusion

- The possibility of investigating the passage of tidal wave in the Earth’s ionosphere using the method of “transmission” by its space radio sources in the decameter wave range using the method of digital registration has been experimentally confirmed.
- The observed effects of severe flickering are associated with the passage of lunar tidal disturbance in the Earth’s ionosphere, containing direct and reverse tidal waves that act like a plasma lens, distorting the shape of the radio source record.
- Observational data show that the size of the tidal perturbation is approximately 30-60 degrees in right ascension and declination from different sources.

References
Brunelli B.E., Namgaladze A.A.: Ionosphere Physics, Moscow: Nauka, 1988, Chapter 5. Neutral atmosphere and processes in it. Tides. p. 281-288.
Akasofu S.I., Chapman S.: Solar terrestrial physics. Oxford, 1972, Chapter 4. Dynamics of the upper atmosphere and dynamo effect. Tidal vibrations of the atmosphere p. 343-368.
Sidorenkov N.S. Atmospheric processes and the Earth’s rotation. St. Petersburg: Hydrometeoizdat, 2002. Chapter 4 Tides and Earth’s rotation. p. 75-121.
Dunkan R.A.: Lunar variations in the Ionosphere. Austral- ian Journal of Physics, 9, 112.