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Tidal phenomena in the Earth's upper atmosphere

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From 1987 to the present, the radio flux of powerful galactic and extragalactic radio sources is monitored at decameter waves at the URAN-4 radio telescope of the Odessa Observatory of the Radio Astronomy Institute of the National Academy of Sciences of Ukraine. The work is based on revealing the nature of unusual records of radio sources that were not associated with the presence of interference in the decameter radio band. Changes of fluxes of radiation sources at decameter waves are determined by the condition of an ionosphere as a result of variation in space weather 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. This effect was originally reflected in earlier works [1]. In this paper the analog records of radio sources (1987–1990) and digital (1998–2004) are considered and various tidal effects were clarified. Based on the results of measurements, the angular dimensions of the tidal wave, reaching 60 degrees, were determined. Radio astronomy observations in the decameter range at the URAN-4 radio telescope are an effective method for studying tidal phenomena in the Earth's upper atmosphere.

Keywords: Atmospheric 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 [2, 3].

The passage of a tidal wave gives a pressure change of 13.4 μb with a probable error of 2.7 μb. At the same time, the maximum ballometric pressure was observed half an hour before the upper and lower culminations of the Moon. The amplitude

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and time of passage of the tidal wave depends on the geographic latitude. In the upper atmosphere, the effect of tidal phenomena increases. Tides are detected by observations of cosmic rays and the allocation of wind speed in the upper atmosphere. Ionospheric layers are detected using vertical sounding stations operating in the range of 1–20 MHz [4, 5]. Vertical sounding stations are non-directional and record only the integral effects of tidal disturbances, so the measured quantities are second-order quantities. The integral methods also include the measurement of variations in the density of the upper atmosphere from observations of satellite movement. The study of the effects of the passage of a tidal wave in the Earth's ionosphere is also possible by the method of "transmission" of its cosmic radio sources in the decameter wave range. Thus, the data of radio astronomical observations at the Uran-4 radio telescope are an effective method for studying tidal waves arising in the ionosphere.

From 1987 to the present, the radio flux of powerful galactic and extragalactic radio sources is monitored at decameter waves at the URAN-4 radio telescope of the Odessa Observatory of the Radio Astronomy Institute of the National Academy of Sciences of Ukraine. The monitoring program includes radio galaxies 3C274, 3C405 and supernova remnants 3C144, 3C461. Observations of these radio sources provide a uniform round-the-clock coverage in time and allow us to record the state of the ionosphere and the processes occurring in it according to the data of changes in the fluxes of radio sources and their scintillations. Observations were carried out in analog recording mode, and since 1997 in digital mode.

2 Abnormal types of radio source records

The paper considers cases of tidal wave demonstration according to monitoring data of radio sources in analog and digital recording modes, for the periods 1987–1990 and 1998–2004, respectively. Radio source records were chosen as the data under study when they passed near the Moon. These data were characterized by three types of

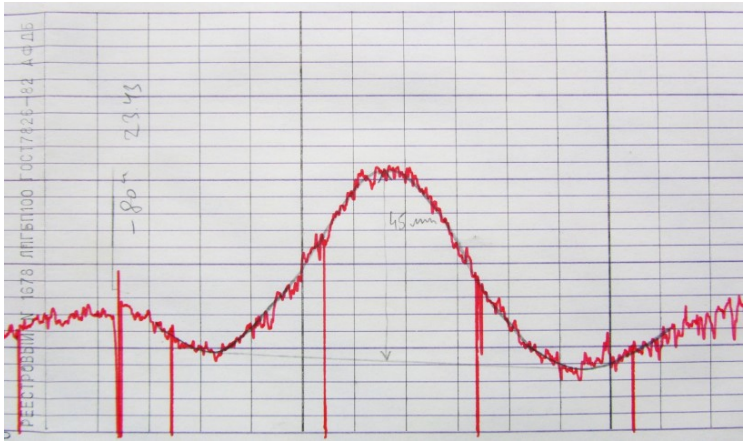


Figure 1 Sample source of normal recording 3S274 – March 22, 1990 (25 MHz – A) – analog data.

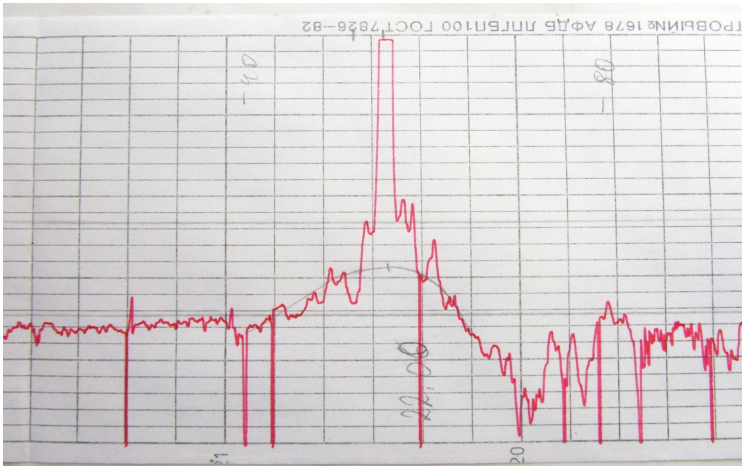


Figure 2 Example of abnomal recording of the source 3C144 – April 22, 1988 (25 MHz – A) – analog data.

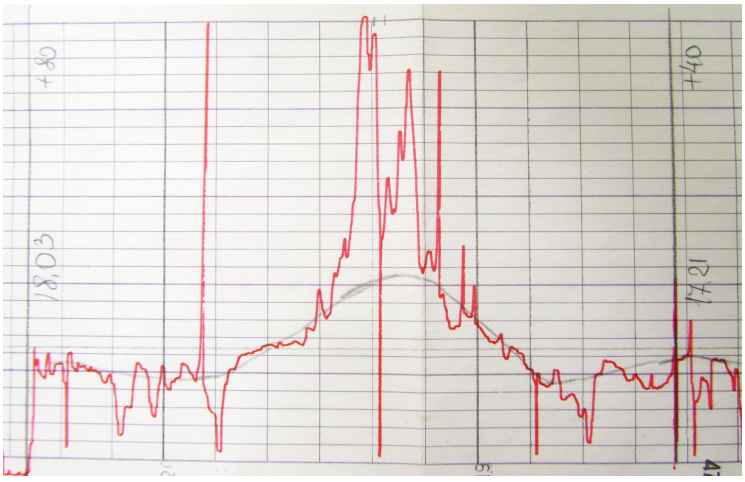


Figure 3 Example of abnomal recording of the source 3C274 – June 22, 1990 (25 MHz – A) – analog data.

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. Examples of recordings of the radiation flux of radio sources are shown in Figures 1–4.

The recorded abnormal records coincided with time of the close arrangement of the Moon and sources on right ascension (Figures 5–9). During periods when observations were conducted 24 hours a day, the effects of a direct and reverse tidal wave were noted.

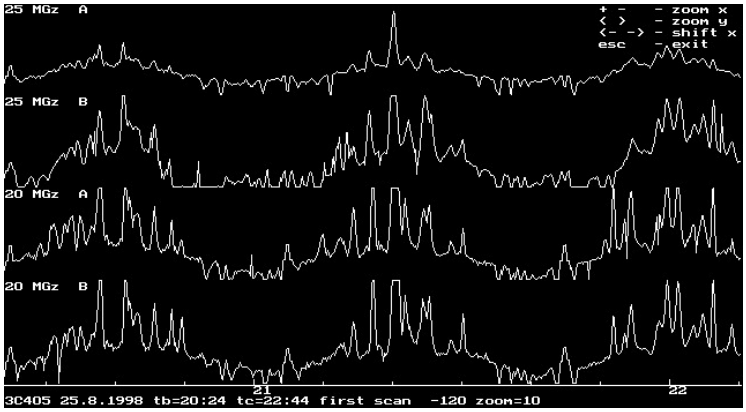


Figure 4 Example of abnomal recording of the source 3C405 – August 25, 1998 (25 MHz – A) – digital data.

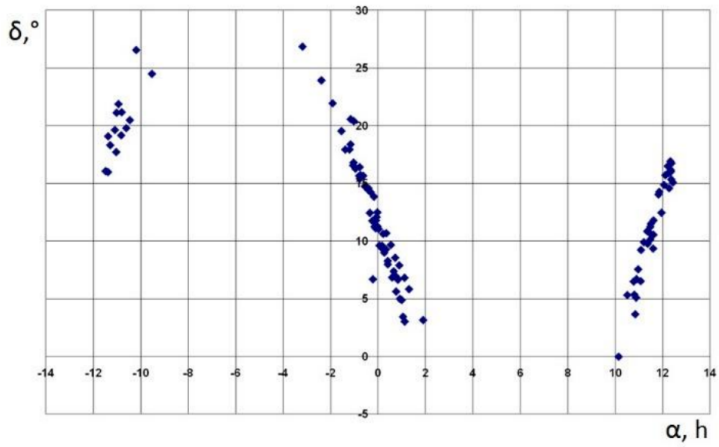


Figure 5 The position of abnormal radio 3C274 records varies depending on the distance between the Moon and the radio source by right ascension (1998–2004) – digital data.

Detection of similar effects at on radio telescope "URAN-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 "URAN-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 at-

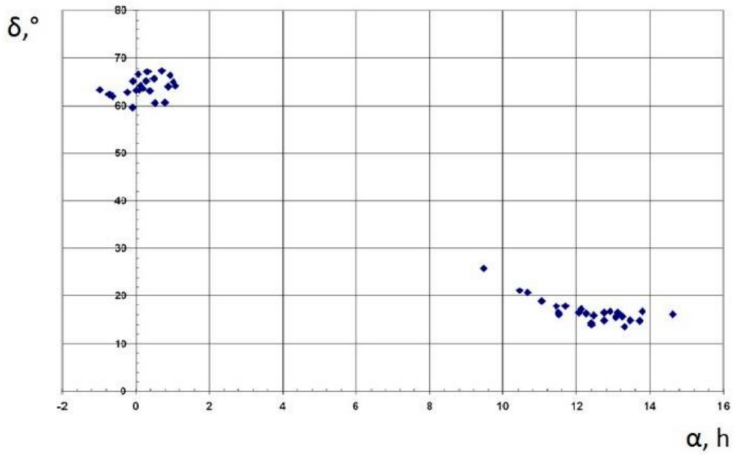


Figure 6 The position of abnormal radio 3C405 records varies depending on the distance between the Moon and the radio source by right ascension (1998–2004) – digital data.

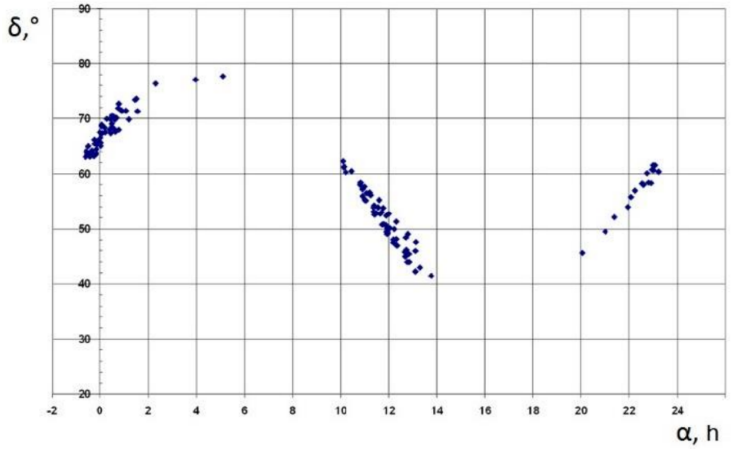


Figure 7 The position of abnormal radio 3C461 records varies depending on the distance between the Moon and the radio source by right ascension (1998–2004) – digital data.

mosphere of the Earth by the method of transmitting the region of tidal disturbances in the ionosphere. 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 the next studies.

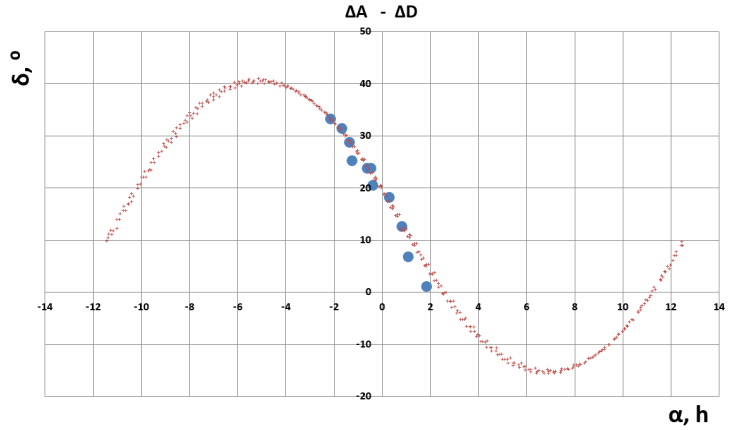


Figure 8 The position of abnormal radio 3C274 records varies depending on the distance between the Moon and the radio source by right ascension (1987–1990) – analog data.

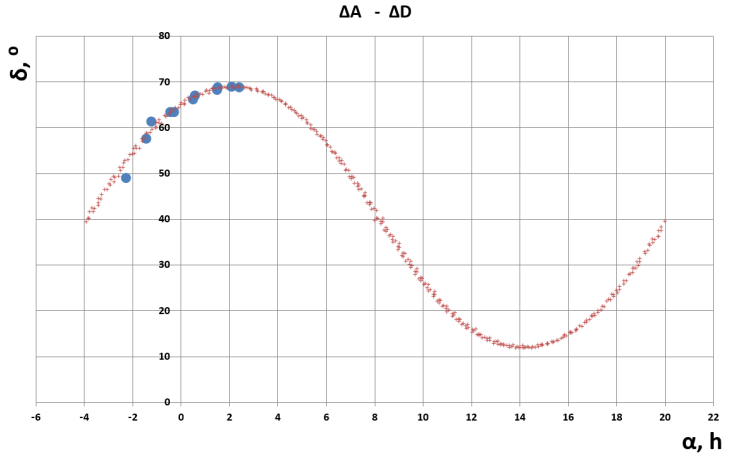


Figure 9 The position of abnormal radio 3C405 records varies depending on the distance between the Moon and the radio source by right ascension (1987–1990) – analog data.

3 Conclusions

As a result of the study of the tidal wave, the following results were obtained.

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.

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