POLYTECH
Peter the Great
St.Petersburg Polytechnic
University

Available online at www.sciencedirect.com

ScienceDirect

St. Petersburg Polytechnical University Journal: Physics and Mathematics 000 (2017) 1–6
www.elsevier.com/locate/spjpm

Radio emission of the group of stars in the Aquarius and Cetus constellations

Anton A. Lipovka[a], Neonila M. Lipovka[b,*]

[a] Center of Physical Studies, University of Sonora, Blvd Luis Encinas y Rosales SN, Centro, 83000 Hermosillo, Sonora, Mexico
[b] Special Astrophysical Observatory of the Russian Academy of Science, Nizhny Arkhyz, Karachay-Cherkessia, 369167, Russian Federation

Available online xxx

Abstract

In the present work, the optical identification of a group of radio sources located in the Aquarius and Cetus constellations in a field with the size of 1.2 square degrees has been carried out. Ten radio sources under investigation were identified with stars and one object was identified with a diffuse image (ESO-538-10). It should be stressed that eight radio objects were found to have a non-thermal radio spectrum. This fact is likely to indicate the presence of the significant magnetic field in the atmosphere of the sources. Precise radio and optical coordinates of the identified objects were suggested. Significant radio refraction in the interstellar medium in the tested space direction was revealed.

Keywords: Coordinate system; Radio source; Optical identification; Interstellar medium; Aquarius; Cetus.

Introduction

In 1609, the prominent Italian physicist, engineer and astronomer Galileo Galilei constructed the first optical telescope and started to observe the celestial objects. In 2009, optical astronomy turned 400 years old, and that year was declared the International Year of Astronomy (IYA2009).

Radio astronomy is a very young science in comparison with optical astronomy. Radio amateurs made substantial contributions to the detection of radio emission from celestial objects. Investigating the environmental noise in 1932, Karl Jansky discovered a radio signal coming from the center of our galaxy. The unit for the flux density of radio sources is the jansky in honor of this researcher. In 1937, using his own funds, Grote Reber built a radio telescope 9.5 m in diameter, and carried out the first sky survey in 1938–1943. At the time, the sensitivity of the receiving equipment did not allow to detect the radio emission of celestial objects in the centimeter wavelength range, so Reber had to conduct his first survey in the meter range. His first study was published in 1944. A mismatch between the coordinates obtained in the radio and the optical wavelength ranges of celestial objects was discovered in the first years of sky observations.

The rapid development of radio astronomy began in 1945. The first objects examined in the radio range were gas nebulae of large angular size, sufficiently bright in this range; there was no difficulty in

* Corresponding author.
E-mail addresses: aal@cifus.uson.mx (A.A. Lipovka), nila_lip@mail.ru (N.M. Lipovka).

http://dx.doi.org/10.1016/j.spjpm.2017.06.003

(Peer review under responsibility of St. Petersburg Polytechnic University).

identifying them with optical objects. However, it soon became clear that the resolving power of radio telescopes had to be increased. The construction of large-scale radio telescopes, such as the Large Pulkovo Radio Telescope (130×3 m) and RATAN-600 (600×10 m), commenced. Nelya Esepkina [1,2] participated in the development of these telescopes.

As the sensitivity and the accuracy of the recording equipment increased, it was found that the influence of the medium on the propagation of radio waves had to be taken into account. For example, Komesaroff's study [3] on the detection of radio refraction in the Earth's ionosphere at a frequency of 19.7 MHz, published in 1960, revealed that this type of radio refraction is quite significant in the meter wavelength range and occurs at altitudes of more than 350 km above sea level. For this reason, the coordinates of the radio objects measured in the meter wavelength range typically differ from the coordinates obtained in the centimeter range.

The Third Cambridge Catalog of Radio Sources (3C) [4] was published in 1962, listing the coordinates of the celestial radio objects that did not have a pair in the optical wavelength range. The catalog was compiled for the meter wavelength range, namely for the frequency of 178 MHz, with a directivity pattern $\Theta = 13.6' \times 4.6°$. The coordinates of the objects in this survey were the result of averaging all radio sources located in a field of size $\Theta = 13.6' \times 4.6°$ in the meter wavelength range. Even though the coordinates of the celestial radio objects were measured with insufficient accuracy and were not identified with optical objects, some objects of the 3C catalog are still used as reference and are used for matching even the radio objects observed in the centimeter wavelength range.

It has now been established that a radio beam in the centimeter range undergoes refraction in the Earth's troposphere, while refraction of radio waves in the meter wavelength range occurs in the Earth's ionosphere.

Very-long-baseline interferometry (VLBI) is rapidly developing. The first observations have proved that correctly matching radio sources to optical celestial objects is of utmost importance.

The first identifications of radio and optical objects

The nature of celestial radio objects can be studied only after they have been correctly matched to optical objects, i.e., after it has been unambiguously proven that the coincidence of radio and optical objects is not accidental. In this regard, the correct optical identification is the first and necessary condition for studying the characteristics and nature of celestial objects.

Historically, these identifications were carried out with reference objects, which often did not have the required coordinate accuracy. This led to a large number of mismatches, called the 'empty field'. It became obvious that it was necessary to develop both a method and a criterion for identifying radio and optical objects. We started the optical identifications in 1985 at the National Institute of Optics, Astronomy and Electronics (Tonantzintla, Mexico) using a Zeiss blink comparator according to standard astrometric practices by Schlesinger's method. We used the data of a highly sensitive sky survey, obtained with the RATAN-600 radio telescope at a wavelength of 7.6 cm [5].

The blink comparator allowed to determine the coordinates of optical objects obtained from Palomar glass plates with the accuracy

$$\sigma \mathrm{RA} \times \sigma \mathrm{DEC} = 1.5'' \times 1.5''.$$

As a result of our studies, we were able to conclude that the radio objects did not match the optical ones, and therefore the radio objects fell into the empty field in the optical image.

In 1987, observations were carried out for a number of optical objects with a diffuse image ('galaxies') using the Bonn 100-meter radio telescope. It turned out that the coordinates of the radio objects determined by this radio telescope also fell into an optically empty field and did not coincide with the galaxies visible during optical observation, even though it were these precise galaxies that the radio telescope was set to.

We continued the optical identifications of radio and optical objects using a blink comparator in 1990 and 1993–1994. Out of 800 radio sources that we examined, obtained from the observations with RATAN-600, less than 8% could be identified, with poor accuracy. The majority of the radio sources fell into optically empty fields.

To date, a large amount of radio astronomical observations of celestial objects has been accumulated for a wide range of wavelengths (from the meter to the millimeter range), carried out with high sensitivity and high resolution by various telescopes [6]. However, as it turned out, the greater part of the radio sources have not been identified with the celestial objects visible in the optical wavelength range. A generally accepted explanation for this is that the primary sources of radio emission at galactic latitudes $b > 2°$ are extragalactic objects, such as active galaxies and quasars ('Nearly