АСТРОФИЗИКА

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OPTICAL IDENTIFICATION OF THE IRAS POINT SOURCES BASED ON THE FIRST BYURAKAN SURVEY

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Optical identification of infrared sources from the IRAS Point Source Catalogue (PSC) is made by means of low-dispersion spectra of the First Byurakan Survey (FBS) and Palomar Observatory Sky Survey (POSS) red and blue images. The purpose of this work is to examine the composition of the PSC sample of fainter sources at high galactic latitudes and to reveal QSOs, infrared galaxies, red stars (C and M), planetary nebulae, for their further investigation at the optical range. 100 of 108 unknown IRAS sources in the region with $3^h50^m \le \alpha \le 7^h40^m$ and $+69° \le \delta \le +73°$ are optically identified. Optical coordinates, V magnitudes, colour indices and preliminary classes are determined. According to preliminary classification 3 objects turned out to be QSOs, 36 - galaxies with very interesting morphology, 5 - faint planetary nebulae, 9 are carbon stars and 47 - late M-type stars.

1. *Introduction.* During the fulfilment of the second part of the FBS [1] (a search and investigation of the stellar objects on the FBS plates) the author revealed, that the limiting magnitude of the survey in some regions is significantly higher, than it was considered before (17^m-17.5^m) [2]. Some plates have m_{lim} up to 19^m and the mean m is 18^m-18.5^m. These regions are those, where B.E.Markarian started the survey in 1960's with Kodak IIF and Kodak IIAF emulsions. The realization of the Second Byurakan Survey (SBS) [3] in the region of $8^h00^m \le \alpha \le 17^h00^m$ and $+49^0 \le \delta \le +61^0$ also depended on this circumstance. According to our analysis, plates with deep limiting magnitudes are obtained also upon a large surface in three zones ($+61^0 \le \delta \le +73^0$) of the FBS, where the selection of stellar objects is already made.

It is known also, that many Markarian galaxies are infrared sources, as well as some IRAS PSC [4] sources were revealed among the objects of the second part of the FBS. The author examined the correspondence of the IRAS fluxes at 12μm, 25μm, 60μm and 100μm to the optical magnitudes of the FBS low-dispersion spectra for identified objects. The results were rather hopeful: the FBS observational material can serve with success as a base for optical identification of the PSC unknown sources, as the faintest sources in average have m_{pg} near the limit of the FBS good plates. The identificitaion is to be done by means of the FBS low-dispersion spectra, as well as using the images and approximate colours from the POSS charts.

2. *Identification principles.* FBS plates are obtained on Byurakan 1 m Schmidt telescope equipped with 1.5° objective prism. They have 4°x4° sizes and Kodak IIF, IIAF, IIaF and 103aF emulsions. The dispersion of the FBS spectra is 1800 A/mm near H_γ and the scale is 97"/mm. Thus, taking into account, that the spectral range is 3400-6900 A (with a green gap at 5300 A), the prism spectra have 1.7 mm length. The linear resolution of the photographic emulsion is about 25μm. So the magnification of 15^x allows to notice many details of the spectra. The large spectral range allows also to follow and estimate the distribution of the energy in spectrum and separate plane, powered and other types of spectra, as well as to take into account the presence of emission and absorption lines. So it is rather easy to recognize the red stars, and also to separate C and M types among them. Thus the FBS low-dispersion spectra are good indicators of carbon and M stars, planetary nebulae, sometimes - QSOs, and galaxies, objects, which correspond to infrared sources. The mentioned types of objects are not numerous, so it becomes possible to distinguish the optical counterparts in the IRAS coordinates uncertainty boxes, where mostly only one candidate is situated. It is important also, that the accuracy of coordinate determination is high (1^s - 2^s for α and about 10" for δ) and the fulfilment of the second part of the FBS gave an experience of recognition and classification of the low-dispersion spectra.

3. *Main Results.* The list of 100 IRAS PSC sources, identified by above mentioned way, is beeing prepared to publication and will appear in Astrofizika. Optical coordinates, *V* magnitudes, colours and preliminary types from the low-dispersion spectra are determined for these objects. The objects are situated in the region of the FBS $+69^0 \le \delta \le +73^0$, $3^h50^m \le \alpha \le 7^h40^m$ and occupy a surface of 75 sq. degree. 3 of the IRAS sources turned out to be QSOs, 36 - IR galaxies, 5- planetary nebulae, 9 - C and 47 - late M stars. Many galaxies have very interesting morphology (with HII regions, various irregulars, Seyfert-like bright nuclei, interacting pairs etc). It must be mentioned, that the region is started with the edge of the FBS survey, i. e. with the edge of the Milky Way, where the galactic *b* is not so large. So with the continuation of the identification to higher galactic latitudes the percentage of the galaxies and quasars will increase. In the

investigated region galactic latitudes are from $b=+12°$ to $b=+30°$.

The errors of our coordinate determination are 2^s for α and $10''$ for δ. The accuracy of the IRAS coordinates do not differ highly from ours, so not always the selected optical counterpart for the infrared source will be in the uncertainty box. So 15 identified sources come outside the uncertainty ellipses. The m_V magnitudes of the objects are determined by the relation "image diameter-magnitude" according to [5] as 8.2^m -21.3^m . Fig. 1 shows the distribution of the objects with respect to the m_V-s. The colour indices are estimated in a range of 0.0-$+5^m.2$, which can be transformed to B-V colours as follows:

$$B\text{-}V = 0.6\ CI + 0.07$$

As it was mentioned, 61 sources are identified with Galactic and 39 - with extragalactic objects. The types of the 9 carbon stars are also estimated (5 - R-type and 4 - N-type). Galaxies are preliminary classified by means of the POSS images as follows: 14 - ellipticals, 15 - spirals, 2 - irregulars and 5 - Seyferts. The ellipticals may turn out to be other types in the case of detailed classification. The Seyferts are suspected from the bright nuclei and low-dispersion emission spectra. It must be mentioned also, that identified 11 M and C stars are FBS objects and will appear in the next list of late-type stars after Abrahamian and Gigoyan [6].

The sample is investigated also on various IRAS colour-colour diagrams in order to separate various classes of objects. Particularly [12]-[25] / [25]-[60] dia-

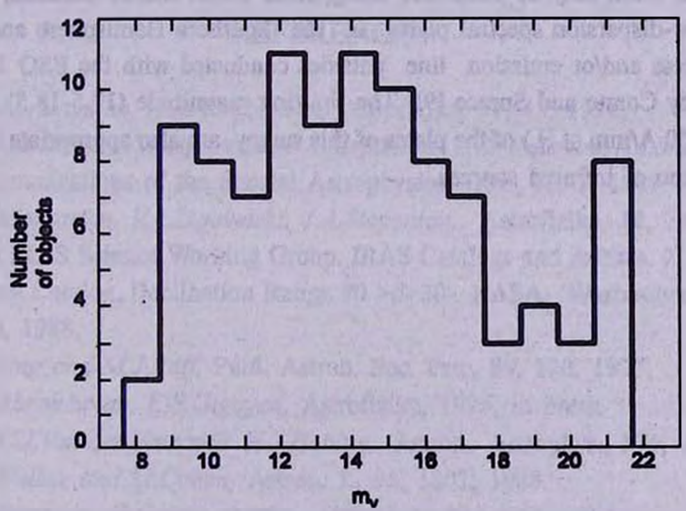

Fig. 1. Distribution of 100 IRAS sources by the optical magnitudes m_V.

gram gives regions for different classes of objects. Late-type stars have large 12μm and 25μm fluxes and smaller 60μm and 100μm fluxes. The stars with dust shells have increased infrared radiation and may deviate from the region of red stars without dust shells. The dust-rich starburst galaxies can be recognized by their IRAS 60μm and 100μm large fluxes in comparison with smaller 12μm and 25μm fluxes, as the ultraviolet flux is partly absorbed by the dust which reradiates in the far infrared (60-100μm). These differences are well seen for example in the papers of Van der Veen and Habing [7] and Walker and Cohen [8]. So the optical characteristics (magnitudes, colours, morphology, low-dispersion spectra) together with the IRAS data on 12μm, 25μm, 60μm and 100μm fluxes, give possibility of immediate classification of the objects and further many-sided research.

4. *Conclusions and perspectives.* As it was seen, low-dispersion spectra are very convenient base for recognition and identification of infrared sources. 100 of 108 IRAS PSC faint sources are identified, 94 of which are confident identifications. The large observational material obtained by means of IRAS needs further investigations, especially at the optical range, in order to discuss the results together with known astronomical objects and phenomena. So such works are necessary and important. For the successful continuation of this work it is desirable to have the digitized POSS. The beginning of the work in Byurakan is made without it and cannot be continued for large amounts of objects. The presence of the POSS and the PSC on CD ROMs together with the FBS plates input by scanner into the computer will give possibility for automatic identification of the IRAS sources.

Similar work may be done also using other observational material, such as the ESO's low-dispersion spectral plates in the Southern Hemisphere and the survey of UV excess and/or emission line galaxies conducted with the ESO 1 m Schmidt telescope by Comte and Surace [9]. The limiting magnitude (17.5-18.5) and the dispersion (450 A/mm at H_γ) of the plates of this survey are also appropriate for optical identification of infrared sources.

ОПТИЧЕСКИЕ ОТОЖДЕСТВЛЕНИЯ ТОЧЕЧНЫХ ИСТОЧНИКОВ IRAS, ОСНОВАННЫЕ НА ПЕРВОМ БЮРАКАНСКОМ ОБЗОРЕ

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Выполнены оптические отождествления инфракрасных источников из Каталога Точечных Источников (PSC) ИРАС, основанные на низкодисперсионных спектрах Первого Бюраканского Обзора (FBS) и красных и голубых изображениях Пломарского Обзора Неба (POSS). Целью настоящей работы является анализ состава выборки относительно слабых источников PSC в высоких галактических широтах и выявление квазаров, инфракрасных галактик, красных звезд (С и М), планетарных туманностей, для их далнейшего изучения в оптическом диапазоне. Из 108 неизвестных источников ИРАС в области с $3^h50^m \le \alpha \le 7^h40^m$ и $+69° \le \delta \le +73°$ оптически отождествлено 100. Определены оптические координаты, звездные величины *V*, показатели цвета и предварительные классы. Согласно предварительной классификации, 3 объекта оказались квазарами, 36 - галактиками с интересной морфологией, 5 - слабыми планетарными туманностями, 9 - объектов являются углеродными звездами и 47 - звездами М поздних подклассов.

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