30 years studying of galaxies at Rozhen NAO

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Abstract. This survey is devoted to the 30-year anniversary of the Rozhen NAO. The contributions of the Bulgarian astronomers in the observational extragalactic studies are reviewed. The five main projects of the investigations include individual galaxies, nearby galaxies, active galactic nuclei, voids and large scale structures, and Bulgarian virtual observatory. More than 80 Bulgarian authors and 340 scientific papers have been reviewed. All the results are grouped in 17 directions and a lot of special tasks. The greatest part of the results are based on the observations at Rozhen NAO and Belogradchik AO.
Key words: galaxies-observation; system of galaxies

Introduction

Observational study of galaxies and systems of galaxies is traditional for Bulgarian astronomers. Extragalactic astronomy is the field that deals with objects beyond the Milky Way, especially galaxies and quasars. Such investigations before the regular exploitation of the National astronomical observatory Rozhen have been made in the former Soviet Union observatories. Since 1980 the main directions of our extragalactic investigation have become astrophysics of galaxies and systems of galaxies and AGN. These investigations include physical processes and chemical abundance in galaxies, systems of galaxies, photometry and surface photometry of normal and active galaxies and galaxies in voids, disk profiles and star formation, structures of galaxies and clusters of galaxies, etc. Parallel investigations of nebulae, stars and stellar associations in the nearby galaxies have been carried out. The program looking for novae in M 31 and M 33 galaxies and the investigations and searches for star clusters in nearby galaxies continue.

The investigations mentioned above were organized in several projects – Individual galaxies, Nearby galaxies, Active galactic nuclei, Large scale structure of the Universe and finally – Bulgarian virtual observatory.

This review draws our attention to the contributions of the Bulgarian astronomers in the field of observational extragalactic studies. Theoretical works concerning clusters of galaxies and the physical processes in the early Universe are not included here.

1 Basic directions of investigations – projects and tasks

Some details concerning subprojects of our investigations are following:

- ***Project Individual galaxies:*** Box/Peanut galaxies, Open clusters, Galaxy Spectra, Gravitational Lenses, Surface photometry, Star Formation, Chemical abundance, Masses of galaxies, Gaseous Nebulae, Pairs of galaxies, High Surface Brightness Galaxies, Electro-photometry of galaxies, etc.
- ***Project Nearby galaxies:*** Dwarf Galaxies, Profile decomposition, Scaling relations, Novae in M 31 and M 33, Spiral structure, OB associations in galaxies, etc.

- ***Project Active Galactic Nuclei:*** Variability monitoring of quasars and blazars, Surface photometry of AGN, Eigenvectors determination, Black hole masses, AGN environment, etc.
- ***Project Voids and Large Scale Structure:*** Galaxies in Voids, Cluster analysis, etc.
- ***Bulgarian Virtual observatory:*** Galaxian Virtual Observatory, Bulgarian GRID.

Details for all projects and tasks can be found in the WEB pages of the author - http://www.astro.bas.bg/~petrov/, Department of astronomy of the Sofia University - http://phys.uni-sofia.bg/~astro/ and Department Galaxies of the IA and NAO - http://www.astro.bas.bg/galaxies/.

The astronomers from the Institute of Astronomy with Rozhen NAO and from the Department of Astronomy of the Sofia University work in close collaboration. Tens of scientists from Germany, Russia, Austria, Norway, Sweden, Turkey, Armenia, Italy, France, England, Poland and many other countries visited our observatory and took part in a lot of cooperative works too.

2 Scientific potential for extragalactic investigations

During the last 30 years a school of Bulgarian extragalactic astronomy was created. Bachelor and master of science degrees have been adjudicated to 18 students, 15 PhD students completed their education at Sofia University and Institute of Astronomy with NAO and 15 PhD dissertations have been defended. In Fig.1 the above mentioned people are listed.

Our investigations were carried out at the two Bulgarian observatories – Rozhen NAO and Belogradchik AO with different ***telescopes and equipment***:

2.1 Rozhen NAO

50/70 cm Schmidt telescope - 16x16 sq.cm, 4x4 sq.deg.

- ST-6 CCD, BVRIHa filters, 375x242 sq.px ; 8.6 x 6.5 sqr.mm
- ST-8 CCD camera with higher B_sensibility; 1530x1020 sq.px, 9x9 sq.mkm pixel size
- SBIG CCD camera STL-11000M, 4008x2672 sqr.px., 9x9 sqr.mkm pixel size
- CCD camera FLI PL 16803, 4096x4096 sqr.px., 9x9 sqr.mkm pixel size

60 cm Cassegrain telescope

- UBV- and dual channel photometer
- CCD camera FLI PL 9000, 3056x3056 sqr.px, 12x12 sqr.mkm pixel size

2m RCC telescope

- direct plates 30x30 sq.cm, UBVRI filters, 1x1 sq.deg.
- Photometrics CE200A CCD_camera, 1024 x 1024 sqr.px., 24x24 sqr.mkm pixel size
- VersArray CCD camera, 1340 x 1300 sqr.px., 20x20 sqr.mm pixel size
- Image Tube Systems XX-1050, XX-1063 (Phillips) and UM-92
- GRISM

PhDs in the field of Galaxies

Bachev	Rumen	Popov	Vasil
Efremova	Borjana	Slavcheva	Luba
Golev	Valeri	Tomov	Aleksandar
Koleva	Mina	Tzvetanov	Zlatan
MIhov	Bojko	Valchanov	Ivan
Ovcharov	Evgeni	Valcheva	Antonija
Pessev	Petar	Yankulova	Ivanka
Petrov	Georgi		

PhD_students in the field of Galaxies

Bachev	Rumen	Panajotova	Marijana
Disanska	Maria	Pessev	Petar
Efremova	Borjana	Slavcheva	Luba
Goranova	Juliana	Stanchev	Orlin
Ilchev	Lazar	Valchanov	Ivan
Koleva	Mina	Valchanov	Tony
MIhov	Bojko	Valcheva	Antonija
Ovcharov	Evgeni		

Students in "Galaxies" Department

Tomova	Mima	1981	Dimitrov	Dimitar	1996
Tasheva	Radostina	1984	Slavcheva	Luba	1996
Velichkova	Kalinka	1988	Pesheva	Mariela	1997
Zamanova	Vanja	1990	Ivanova	Rositsa	1997
Micheva	Evilina	1991	Georgieva	Ekaterina	1998
Petrov	Ivajlo	1994	Dimitrov	Vencislav	2000
Bachev	Rumen	1994	Koleva	Nina	2003
Vasilev	Oleg	1995	Koleva	Mina	2004
Takiev	Branko	1996	Karavasilev	Nikolaj	2010

Fig. 1. Students, PhD students and PhDs in extragalactic astronomy

2.2 Belogradchik AO

60 cm Cassegrain telescope

- UBV photometer
- ST-8 CCD, BVRIHa filters, 1530x1020 sq.px, 9x9 sq.mkm; 13.8x9.2 sq.mm
- CCD camera FLI PL 9000, 3056x3056 sqr.px, 12x12 sqr.mkm pixel size, BVRcIc Johnson-Cousins standard filters

  40 cm Celestron telescope
- 'STAR-1' CCD, 512x376 sq.px, focal reducer and spectrograph

2.3 Software

IRAF, MIDAS, IDL and a lot of different special programs and packages. The basic operational system for scientific investigations is LINUX and the Scientific Linux is the basement of the Bulgarian GRID.

3 Basic contributions of the Bulgarian astronomers

During these 30 successful years more than 70 Bulgarian authors are authors or/and coauthors of 340 scientific papers. The full list of publications with at least one author/coauthor whose affiliation is Sofia University or/and the Institute of Astronomy and NAO could be found in the WEB page of the author - http://www.astro.bas.bg/petrov/.

Figure 2 presents the contribution of the Bulgarian authors with more than 15 publications in the field of observational extragalactic astronomy. [1]

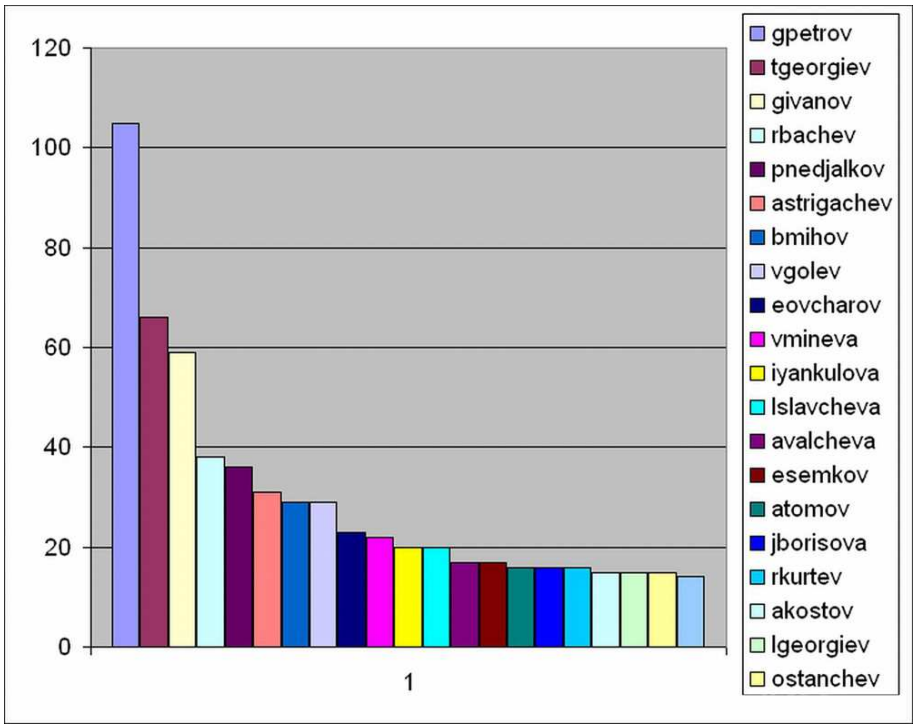

Fig. 2. Distribution of extragalactic investigations publications

[1] All pictures below are composed for illustration purposes only – if interested one could take the pictures from the original papers.

Following are the main contributions of our investigations, grouped in 17 directions:

3.1 Astrophysics of gaseous nebulae

Abundances of some ions (He +; O +; N +; S +, etc.) for 50 diffuse nebulae in our galaxy and 45 diffuse nebulae in nearby galaxies have been determined (Golev et al., 1980; Yankulova et al., 1981).

Physical conditions and chemical composition were determined for 114 nuclear HII regions, including in 14 Arakelian, 31 Markarian and 40 nearby galaxies (Petrov et al., 1984).

3.2 Kinematics and dynamics of stellar systems

The rotation curves were examined and the parameters of the gas component and the masses of the galaxies NGC 1084, 5879, 6503, 7339, 7537 were determined. All galaxies contain a lot of neutral gas in the disk, while the gas in the nucleus is not so much (Petrov et al., 1989).

The masses and the rotational momenta for 47 Seyfert X-ray galaxies, 84 Markarian, 21 Arakelian and 13 normal galaxies were determined (Mineva & Petrov, 1990; Petrov & Mineva, 1988, 1991).

3.3 Electrophotometry of double and triple galaxies

U, B, V photometry for about 200 double and triple galaxies has been carried out. Evaluation of their behavior on the two-color diagram was made (Tomov & Tomov, 1989; Tomov & Tomova, 1990).

The surface brightnesses and the diameters of 75 double and 15 triple systems were defined (Tomov, 1979, 1983).

3.4 Study of stellar complexes and associations in nearby galaxies

M 31 – Andromeda galaxy

- The brightest blue and red stars in the galaxy M 31 - Andromeda, were catalogued. The brightest blue star in M31 has M(v) = -9. The survey confirms that the brightest red star has M(v) = -8 (Nedialkov et al, 1989).
- The existence of a gradient in the surface brightness of the spiral arm S4 was found and many OB-associations were located. The distribution in spiral arms is expected to describe a spiral density wave. The parameters of the spiral density wave estimated, showing that the angular velocity of the spiral structure ranges from 7 to 15 km/s/kps (Ivanov, 1985; Georgiev et al., 1989).
- Two hundred and ten groups were detected as real O-associations the mean diameter of which is 80 pc. Many of Hodgeś open clusters were also reclassified as O-associations. Almost all O-associations are located inside the star complexes (Efremov et al., 1987).

- UBV photometry of 521 stars in the spiral arm S5 of the Andromeda galaxy was obtained. The color-magnitude and color-color diagrams have been constructed (Kourtev et al, 1986).
- BVR - photometry was carried out for 100 bright object in the nuclear region of M 31.
- The properties of the disc were determined - namely: opacity, extinction law and gas-to-dust ratio are studied by means of optical and near-infrared photometry (Veltchev et al., 2004; Nedialkov et al., 2005, 2009)
- Investigation of sources of soft X-ray radiation in M 31 was performed (Nedialkov et al., 2002).
- The distribution of bright stars and HII regions was examined. The gas / dust ratio wass determined and the optical density of the disk of the galaxy M 31 in Andromeda was obtained (Nedialkov et al., 2000).
- Coordinates and R-band magnitudes (plus BV-bands if available) for 14 newly discovered nova candidates were reported (Valcheva et al., 2010).

M 33 – Triangulum galaxy

- Associations and star complexes in the galaxy M 33 have been studied including the distribution of red supergiants in the galaxy (Veltchev et al., 2009).
- B- and V- photometry for about 3500 and U- photometry for about 2500 young stars have been carried out. The age of the different stellar populations has been determined.
- Using the data for 65,000 stars, a catalogue of blue and red supergiants was compiled. A list of magnitudes and positions for 2112 blue stars, defined by (U-V)$<$0.0 mag, and V$<$19.5 mag, and 389 red stars defined by (B-V)$>$1.8 mag and V$<$19.5 mag was created. Of these, 1156 are candidate O stars on the basis of (U-V)$<$-0.9 mag (Ivanov et al., 1993).
- A catalog of 481 OB associations with over 3,500 blue high luminosity stars was processed (Georgiev & Ivanov, 1991).
- It was shown that about 200 HII regions with characteristic length of about 80 pc coexist with OB associations in M33. U-band photometry for 36 of them and UBV-photometry of 105 bright stars were performed (Ivanov, 1991).
  In Fig.3, compiled from the publications of G.Ivanov and coauthors, the distribution of some stellar complexes and associations in M 33 and M 81 is presented.
- Some activity in the nucleus of the galaxy has been established due to enhanced star formation (Ivanov et al., 1986).

M 81 galaxy

- A composite catalog of 180 star associations in the galaxy M 81 has been compiled. The catalogue gives the positions of associations, their mean angular sizes, and H II identifications (Ivanov, 1992).
- A narrow-band photometry of galaxies in the M 81 group was performed to look for supernovae remnants with negative result, but many objects were catalogued as HII like regions.

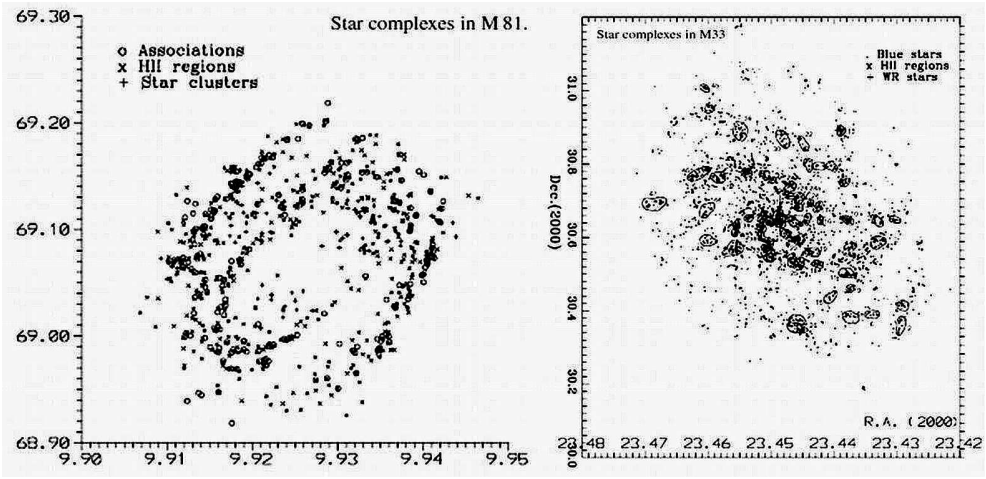

Fig. 3. Distribution of some stellar complexes and associations in M 33 and M 81

- Surveys of the stellar populations in the galaxy M 81 and around it were performed by plates of 6 m (SAO, Russia) and 2 m (Rozhen) telescopes (Georgiev et al., 1992ab)
- The existence of an extensive extra-nuclear emission gas structure with an irregular morphology in the [OIII] line was confirmed in the galaxy M 81 (Georgiev et al., 2005).

Dwarf galaxies and LMC

- U-band photometry of 2500 young stars and BV-band photometry of 3540 stars in the field centred on the HII regions in the north-east sector of the dwarf irregular galaxy IC 1613, a member of the Local Group, was performed and the age of the different stellar populations has been determined. The slope of the initial mass function and the extinction curve for the Large Magellanic Cloud were obtined (Borissova et al., 1999).
- The stallar populations of the dwarf galaxy Ho IX, which is very inportant for the extragalactic distance scale, was investigated by plates of 6 m (SAO, Russia) and 2 m (Rozhen) telescopes in the beginning of a collaboration between Russian and Bulgarian astronomers (Georgiev et al., 1991)
- CCD - photometry of bright stars in 10 nearby late type galaxies has been carried out (Georgiev & Bomans, 2001). Figure4 presents the field of the galaxy M 81 and its close satellite Ho IX, resolved into stars by the 2m Rozhen telescope (Georgiev & Bomans, 2004).
- A detailed kinematic analysis of the ionized gas in the nearby irregular galaxy NGC 4449 was presented (Valdez-Gutierrez et al., 2002).

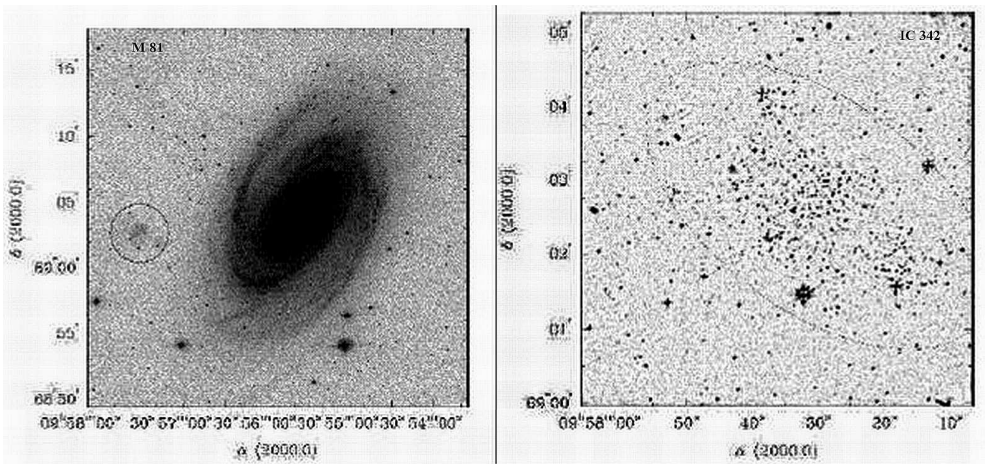

Fig. 4. Dwarf galaxy Ho IX in the periphery of giant galaxy M 81 and Ho IX, resolved into stars by the 2m Rozhen teledcope

- Optical spectroscopy of H II regions in the Local Group galaxy IC 10 and UBVR photometry of foreground stars in three fields towards this galaxy was held (Richer et al., 2001).
- The presence of a rich population of carbon stars in the dwarf galaxy WLM (Wolf-Lundmark-Melotte) was found, based on Js, Ks- photometry of over 550 stars in the galaxy. The number of carbon rich stars compared to oxygen rich ones, scale length, gas/dust ratio and the 'real' distance modulus of the galaxy WLM was determined (Valcheva t al., 2007).

3.5 Surface photometry of nearby galaxies

Using UBVR photographic photometry from the Tautenbourg Schmidt telescope and the 2 m telescope of NAO the mean values of the color indices and their large scale gradients were estimated. The dependence of the axial ratio and the position angle on the semi-major axis were investigated. The results give indirect evidence of existence of a two-armed trailing spiral structure and a bar in M 31. A certain asymmetry of the brightness profiles of the spiral arms of the galaxy M 31 was presented (Georgiev, 1988abc).

By a digital processing of Rozhen plates extended low brightness formations including the bright galaxies of the M 81 group were found and interpreted as intergalactic star complexes(Getov & Georgiev, 1988, 1990).

The morphology of the bright part of the galaxy M 81 was investigated in plates of 3 telescopes and an inner ring and a mini bar were revealed (Georgiev & Getov, 1991).

The luminosity function, the candidates for star associations, and the distance modulus of the galaxy M 51 was determined (Georgiev et al., 1990).

For the 2/3 of the profiles of 'edge on' spiral galaxies the major axes of galaxies are strongly convex. It was found that the radial brightness profile has

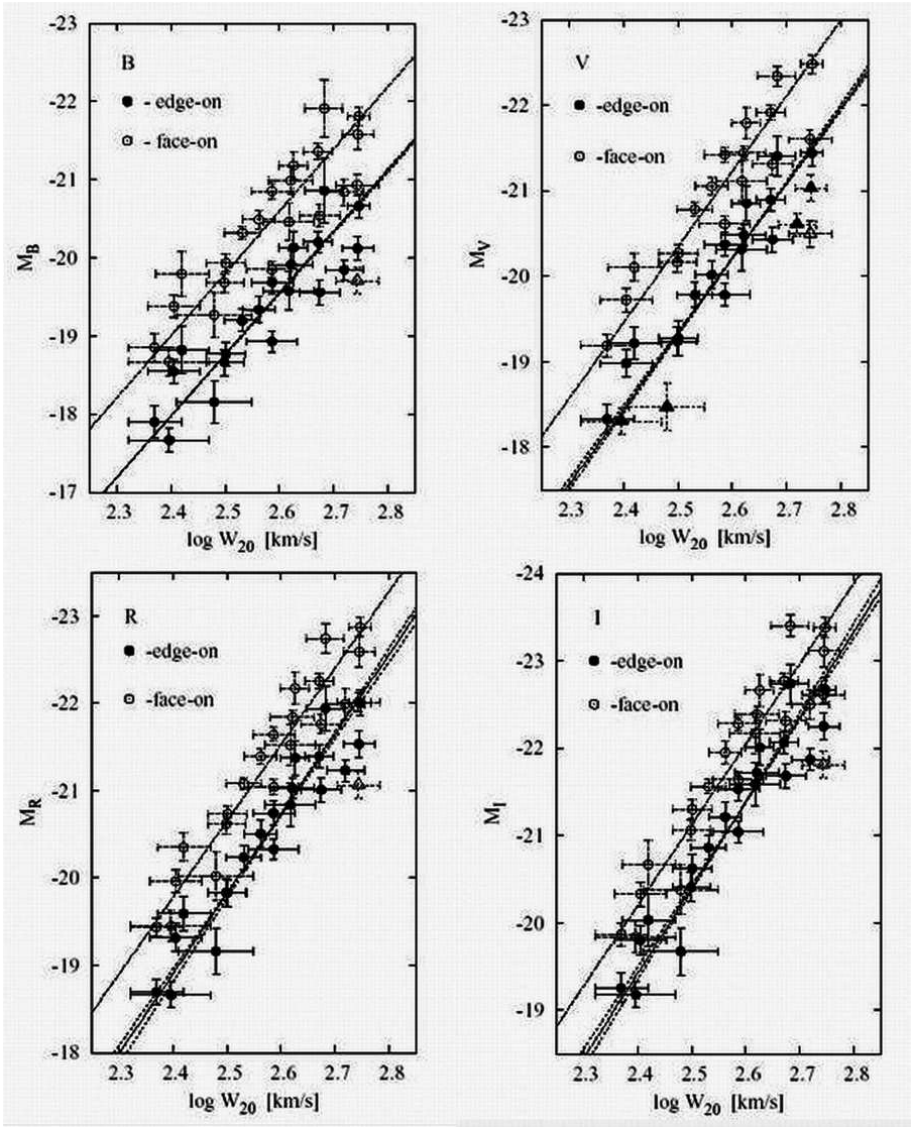

Fig. 5. Tully-Fisher relation for different type of galaxies

an approximately exponential decrease only in the late spiral and irregular disc systems. At the earlier spirals the disk profile becomes more convex (Georgiev et al., 2004).

3.6 Scaling relations and distances to galaxies

It was shown that the luminosity and size of large spiral galaxies visible 'face-off' lie on the Tully-Fisher diagrams with a relatively small dispersion and reassure an independent assessment of the Hubble parameter. About 150 face-off galaxies, and about 110 galaxies with different slopes to the line of sight were examined using data from the literature (Stanchev et al., 2002, 2004a). In Fig.5, compiled from the publications of O. Stanchev and coauthors, the Tully-Fisher relations for different types of galaxies is presented.

The fundamental plane in the space of fundamental parameters (mass, luminosity, size) in spiral galaxies has also been determined (Stanchev et al., 2004b, 2006).

3.7 Structure and evolution of normal and active galaxies

A detailed morphological characterization of a sample of 35 galaxies Seyfert and a corresponding sample of normal galaxies was carried out. A number of photometric and geometric parameters characterizing the galaxies and the parameters of the bars in barred galaxies hawe been determined. New morphological structures in the galaxies were found, thus the morphology classification wass precised. The nearby region to the galaxies was studied for the presence of companions. The results showed that the gas fueling from Seyfert nuclei is not directly related to the large scale morphology of galaxies and the presence of companions (Slavcheva-Mihova & Mihov, 2011a, 2011b).

Using a suitable original software one-dimensional structural decomposition of 5 Seyfert galaxies was carried out and the parameters characterizing the surface brightness distribution of galaxies were defined (e.g. Mihov & Slavcheva-Mihova, 2006).

3.8 Active galactic nuclei

Most of the investigations of the Bulgarian astronomers are concentrated on the physics of quasars, the nature of the blazars and the central black hole of the active galaxies.

- Ions abundances and chemical composition in the nuclei of 36 SyG 1 type, 5 radio galaxies with broad lines, 23 SyG 2 type and 16 radio galaxies with narrow lines were determined (Petrov,1979, 1980).
- The physical conditions and chemical composition in the nuclei of the active galaxies Mark 313, 531, 534, 609, III Zw 103, NGC 7469 and others have been studied in details.(Golev et al., 1984; Mihov et al., 2006).
- Photometry and surface photometry of the galaxies Akn 564, Mark 335, 506, 509, NGC 1275, 6764, 7469, III Zw 2 were carried out and for some of them decomposition of the profiles of the emission lines was made.
- More than 100 HII regions in the galaxy NGC 6764 were discovered (Petrov et al., 2006).
- 98 Seyfert and X-ray galaxies were studied. It is shown that for 50% of them the most likely energy source is the accretion of gas on the central black hole. Accepting a unified model estimation of the black hole mass and accretion rates was made (Petrov & Velichkova, 1991; Bachev & Petrov, 1996).

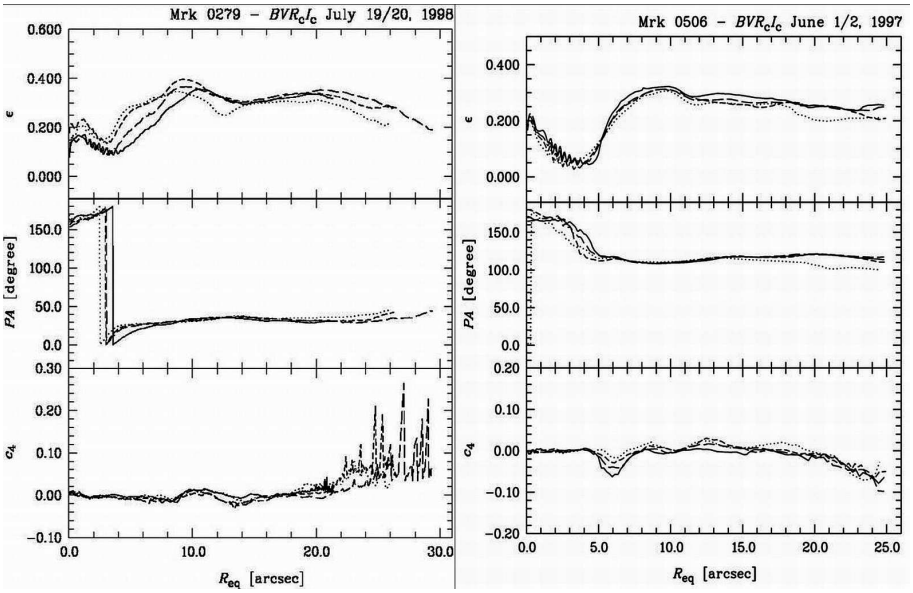

Fig. 6. Surface photometry of the galaxies Mark 279 and Mark 506

– An observational program of extragalactic X-ray sources was proposed (Petrov, 1988).
– In order to build a satisfactory picture of Seyferts in relation to normal galaxies a series of papers established some of their basic environmental properties, especially the difference in the number of close companions between Seyfert 1 and Seyfert 2 galaxies. A sample of 104 Seyfert galaxies and 138 control field galaxies was built (Laurikainen et al., 1994).
– Optical variability of selected active galactic nuclei (quasars) were examined for more than 10 years, mainly on the 60 cm telescope AO Belogradchik. While all objects show a variability on long-term scale, on short scales (within a few hours) as a rule, such changes do not occur for the so-called radio-weak objects (Bachev et al., 2005).
– The optical variability of Mkn 279, where the possible existence of different modes of accretion disk required to explain the color changes of this object, was studied in details. (Bachev & Strigachev, 2004; Mihov & Slavcheva-Mihova, 2006).
– In Fig.6, compiled from the publications of L. Slavcheva-Mihova and coauthors, some results from the surface photometry of Mark 279 and Mark 506 are presented.
– Photometric monitoring of selected quasars and blazars, during the international monitoring blazar program - WEBT, has been systematically carried out. The aim was obtaining light curves of blazars with good coverage at the time (Böttcher et al., 2007; Raiteri et al., 2007). In Fig.7,

compiled from the publications of Mihov and coauthors, the results from the monitoring of the blasar 3C345 are presented.
- The characteristics of the variability of radio quiet active galactic nuclei at different time scales - from within one night to within years, are explored (Bachev,2009).
- Based on archival spectra from the Hubble Space Telescope, the profile of the ultraviolet CIV 1549 line for about 150 objects has been analyzed. It was shown that the profile changes (mainly shifted to the blue) are largely determined by the change of accretion rate (Sulentic et al., 2007).
- Eigenvectors for over 200 objects were determined. It was shown that the major eigenvector probably is mainly related to the rate of accretion, i.e. the accretion rate mainly determines the differences in quasars characteristics (Bachev & Strigachev, 2004; Bachev et al., 2004).
- Spectra of bright, but not well studied quasars, were taken at the observatories Rozhen and Skinakas – Greece. Their central black holes and accretion rates were determined (Bachev et al., 2008).
- The presence of extranuclear emission region in the galaxy Mark 620 was confirmed (Yankulova, 1999).
- A narrow-band photometry of the galaxy NGC 3516 was held, which confirmed the Z-shaped structure of the emitting gas in extended emission lines region (EELR) (Golev et al., 1995c).
- A Fabry-Perot interferometric study of the galaxy NGC 2273- SyG type 2 was carried out (Golev et al., 1995a)
- A spectrophotometric study of the galaxy Mark 817 was conducted (Ilic et al., 2007).
- The presence of a weak bridge between the galaxy Mark 1040 and its companion LEDA 212995 was not confirmed (Popovic et al., 2005).
- There is a progress on the project on measuring the black hole masses of the SDSS quasar sample from their broad emission lines and the continuum luminosity (Ovcharov et al., 2005).

3.9 HSBG – spectrophotometry and Luminosity function

A full spectrophotometric study of the galaxies Akn 144 and 583 was made (Mineva et al., 1982; Petrov et al., 1982; Petrov et al., 2011).

The spatial density was defined and the Hubble diagram was built for 247 Arakelian galaxies and 156 Seyfert galaxies. The two distributions are almost identical. (Golev et al., 1983).

The luminosity function of 284 Arakelian galaxies with known radial velocity was built (Golev et al., 1984).

Spectroscopic study for 22 Arakelian galaxies (Golev et al., 1985) and morphological study of Akn 26, 27, 28, 31, 32, 79 and 144 were conducted (Markov et al. 1985).

A list of additional 47 high surface brightness galaxies in the Nilson system was proposed (Petrov, 1986).

3.10 Chemical abundance of nebulae and emission-line galaxies

Abundances of some ions and the chemical composition of 49 galaxies with emission lines have been determined (Petrov, 1979).

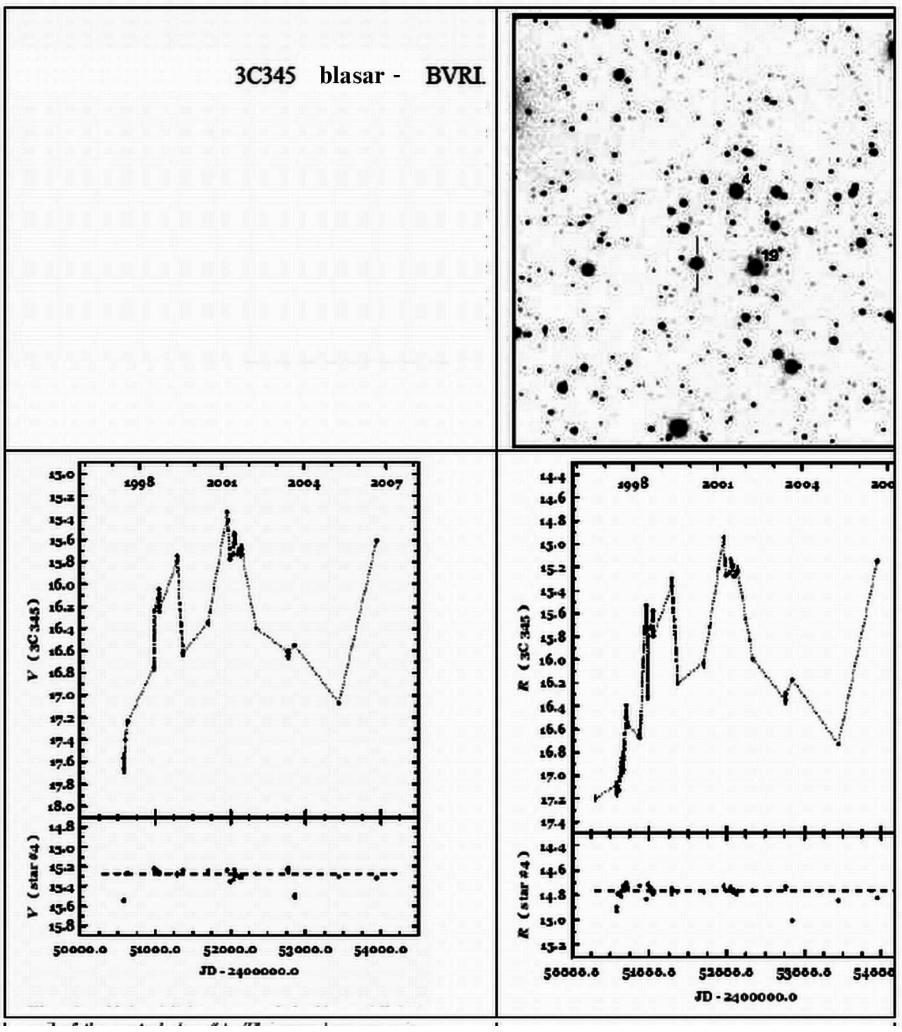

Fig. 7. Monitoring of the Blazar 3c 345 in V and R bands

Detailed analysis of the galaxies NGC 3690 + IC 694 (Mark 171 a, b), NGC 5929, 5879, Mark 558, and others has been made (Yankulova et al., 1980; Petrov et al., 1981;).

Physical conditions and chemical composition of 31 galaxies from the Karachentsev's list of double galaxies have been determined (Petrov et al., 1985).

3.11 Star formation and IR properties

Studies of the star formation rate in 182 High Surface Brightness Galaxies (HSBG) were held. It was found to be 10-30 times higher than that of normal galaxies (Petrov, 1989; Yankulova, 1993).

The star formation for 640 Markarian galaxies from IRAS data was studied. The temperature of the dust of about 50 degrees was defined. According to their IR characteristics (star formation rate, etc.) Markarian and HSB galaxies are closer to the active ones than to the normal galaxies. The presence of a bar in 'nonactive' Markarian galaxies does not lead to higher activity in the infrared region (Petrov, 1991, 1993).

The star formation rate of Karachentsev double galaxies is lower and is comparable to that of bright spiral galaxies of the Virgo cluster (Petrov & Mineva, 1992).

In Fig.8 the star formation regions in the galaxy NGC 7479 are marked.

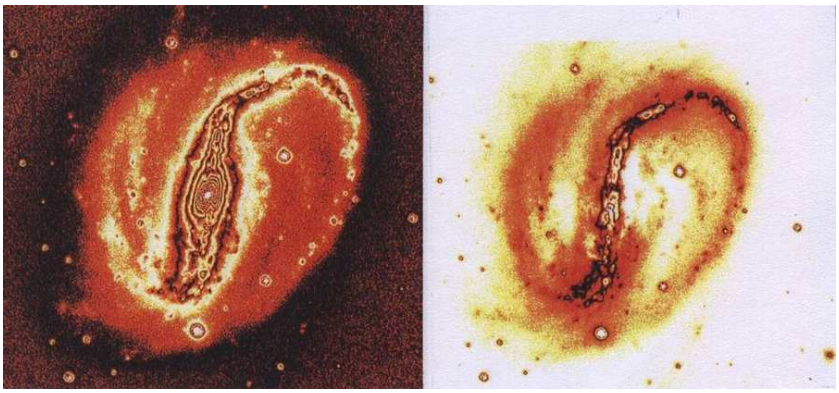

Fig. 8. Star formation regions in the galaxy NGC 7479

3.12 Globular and open clusters

Observational data for 30 open clusters - 7 bright clusters, 7 clusters towards the anticenter and 16 probable double clusters (8 pairs) were obtained to follow the spiral structure of the Galaxy. The sequence of standard stars in NGC 7790 cluster was extended in U and I bands (Petrov et al., 2001).

The age of the clusters King 14, NGC 146, NGC 2383, NGC 2384, Pismis 6 and Pismis 8 was determined (Kopchev et al., 2005; 2006).

BV photometry was carried out and a probable age for the double cluster NGC 7031/NGC 7086 was determined (Kopchev & Petrov, 2006, 2008). UBVRI photometry was performed and a probable age of the double cluster NGC 6755/NGC 6756 was determined. Based on these data, the suspecting "being cluster pairs" is not confirmed (Kopchev et al., 2007). In Fig.9,

compiled from the publications of V. Kopchev and coauthors, the age determination and two-color diagrams for probable double cluster NGC 6755 / NGC 6766 is presented.

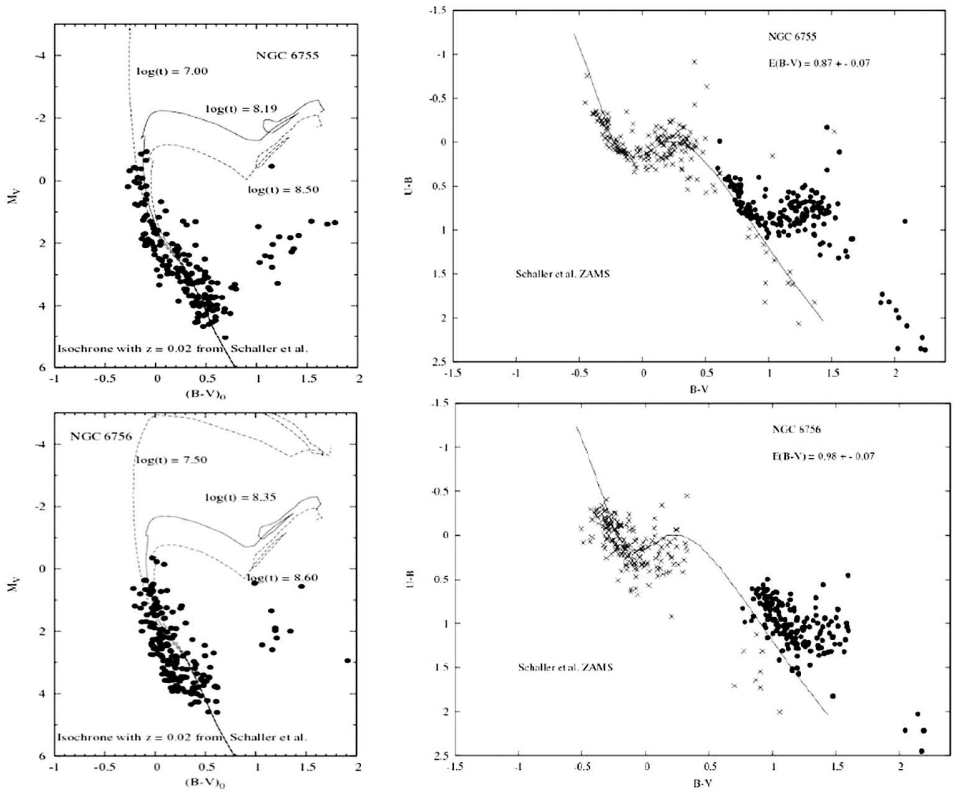

Fig. 9. Age determination for the members of the 'double cluster' NGC 6755/NGC 6756

Studies of ellipticity and morphology of globular star clusters in the Andromeda Galaxy was carried out (Golev et al., 1995; Staneva et al., 1996).

An observational program for studying of open clusters in nearby galaxies and searching for certain types of stars in them was started. The program includes a search for variable stars in clusters too. Twenty eight star cluster candidates were selected, using various methods (Kourtev et al., 2002).

3.13 VOIDS and Large scale structure of the Universe

Nineteen plates with exposures 2.5-3 hours were taken with th 2 m Rozhen telescope for studying of about 10 selected voids were obtained. For comparison under the same conditions the field of the galaxy cluster A 1376 was

imaged too. Limiting magnitude of B = 23 was reached. About 8300 galaxies were classified ob the base of their morphological features as spiral, elliptical, etc., and their diameters were measured (Petrov & Kovachev, 1992; Petrov, 2006).

In the initial treatment 550 galaxies in the field of void centred at 1042-00 and totally 2745 galaxies in the field of void 1306+34, +35, +36 were measured and catalogued (Kovachev & Petrov, 1992; Strigachev & Petrov, 1995). The same was performed for 444 galaxies for 1213+35 (Petrov & Strigatchev, 1993), 2297 galaxies in the void 0049+05 (Petrov et al., 2007). More detailed study were performed for about 1800 galaxies from over 2250 detected galaxies in the Hercules 1600 +18 void (photometry, effective diameters, surface brightness, distribution of the brightness of the galaxy disk etc.(Petrov, 2005).

A cluster analysis of the galaxies in voids 0049 +05 and 1600 +18 was made. The options for selecting low surface brightness galaxies were demonstrated (Petrov et al., 2006; 2007).

3.14 Gravitational lensing

The distribution of mass in galaxies in the lens system 2237 +0305 was examined. Parameters characterizing the mass distribution in the galaxy-lens (central dispersion velocities, mass and mass-luminosity relation for its central parts etc.) were derived. The influence of a probable second lens has been studied determining the parameters characterizing the distribution of its mass (Mihov, 2001a). In Fig.10, compiled from Mihov (2005a), the lens model of the Einstein Cross is presented.

The time delay for the system 0957 +561 was estimated (Slavcheva-Mihova, 2001; Petrov & Strigatchev, 2006). Observations of the Double Quasar 0957+561 at NAO Rozhen following the MEGAPHOT collaboration were made. The possible enhancement of the quasar HS 1946 +7658 brightening, caused by gravitational lensing, was investigated (Mihov et al., 1999; Mihov, 2001b).

A model of Einstein Cross - quasar 2237 +0305 was built (Petrov et al., 1996; Mihov, 2005a).

3.15 BOX / PEANUT galaxies

(U), (B), V, R, I – CCD frames for 30 galaxies - with BOX / PEANUT characteristics and a control sample have been taken and the surface brightness and the brightness distribution over the galaxy disks have been determined (Petrov & Dettmar, 2011).

A detailed study of the galaxy NGC 5610 was carried out (Petrov et al., 2005). In Fig.11, compiled from the publications of G. Petrov and coauthors, some results from analysis of the box/peanut galaxy NGC 5610 are presented.

3.16 GRID and Virtual Observatory

The ideology of the Bulgarian virtual observatory was described. A brief description of over 900 CCD frames for 30 open clusters in our galaxy, hundreds

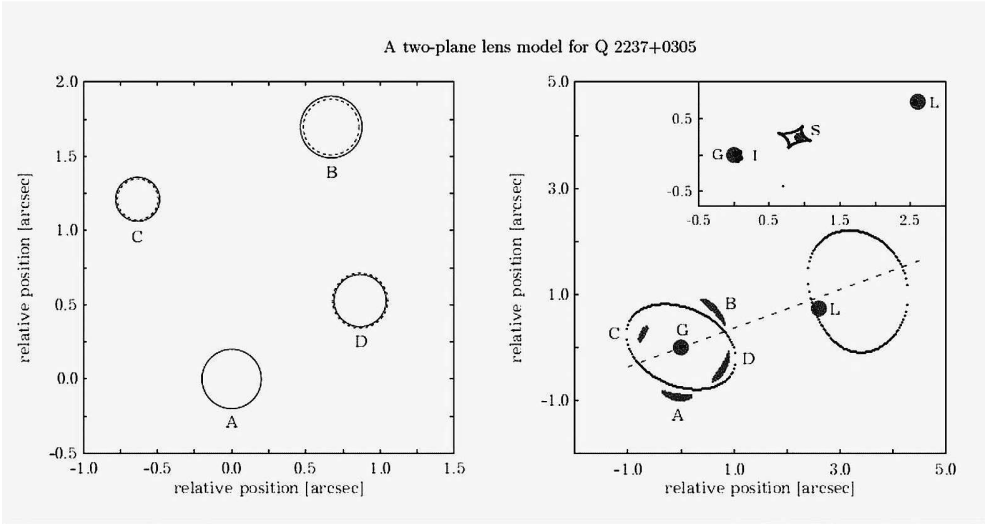

Fig. 10. Lens modeling of the Einstein Cross

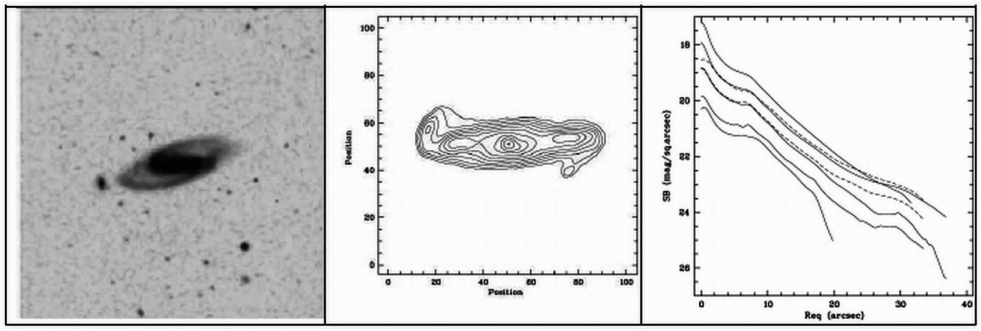

Fig. 11. Study of unusual Box/Peanut galaxy NGC 5610

of CCD frames of quasars - gravitational lenses, over 500 (U, B), V, R, I CCD images of BOX / PEANUT galaxies, over 1800 FITS-files for more than 6000 galaxies in selected voids, about 700 spectra, including 27 spectra of 9 planetary nebulae, 100 spectra of active galaxies and more than 300 spectra of high surface brightness galaxies was presented. All the data are in preparation for unlimited access on the servers of the Institute of Astronomy (Petrov et al., 2009).

The first steps towards the use of GRID for astrophysical models and evaluations were made. (Petrov et al., 2010; Petrov & Dechev, 2010).

Two book- reference materials for GRID and BGVO and Linux operating system for astronomers are in preparation.

3.17 Astronomical maintenance and others

- The construction and calibration of the photographic camera for the 60-cm telescopes, able to image stellar clusters and galaxies, were described (Roussev et al., 2006).
- Observational equipment of an electro-photometer for the Belogradchick 60-cm telescope, able to measure light flows from stars and galaxiess, as well a s its calibration in the UBV system, is constructed and described (Tomov, 1985).
- Astrophysical methods were implemented for the control of the temperature regime during an electron-beam welding (Petrov et al., 1998).
- The calibration of the CCD ST-8 cameras to the Belogradchik 60-cm telescope (noise, temperature dependence, linearity, etc.) and the BVR_cI_c photometric system is described using a photometry of standard stars (Bachev et al., 1999).
- Specialized software was developed to solve different special tasks - primarily designed for different types of statistical analysis of the light curves etc., some of which is available for free use (Georgiev, 1991).
- An aperture photometry program of images - FITS Imager, including patrol observations, was prepared and the program itself locates the stars of interest (Bachev, unpublished).
- Adaptive filter for surface photometry of galaxies was tested and optimized (Slavcheva - Mihova et al., 2006).
- The possibility of spectral observations of galaxies with 2 -m telescope of NAO with a CCD camera and the spectrograph UAGS was studied (Mihov et al., 2006).
- A methodology for processing observations obtained with Fabry - Perot interferometer, was developed and utilized (Golev et al., 1995).

Conclusion

Many years of fruitful collaboration between Bulgarian and foreign astronomers and institutions gave significant results. Extragalactic investigations from the observational point of view continue to be one of the interesting fields toward understanding the Universe. Rozhen NAO gives and will continue to give an important contribution in studying the physical processes in galaxies and their systems.

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