ASTRONOMY IN UKRAINE: GEO SPACE AND TIME SPANS

YAROSLAV YATSKIV

MAIN ASTRONOMICAL OBSERVATORY OF NAS OF UKRAINE
27 AK. ZABOLOTNOGO ST., KYIV 03143 UKRAINE

IN COLLABORATION WITH IGOR LUK’YANYK AND IRYNA VAVILOVA
HISTORICAL NOTES
ARCHEOASTRONOMY FINDS AT THE SETTLEMENTS IN THE TERRITORY OF UKRAINE. PALEOLITHIC ERA

A map showing Paleolithic settlements in the territory of Ukraine, including Dobranichivka, Gontsy, Kiev-Kirillovskaya, Kiik-Koba, Kodak, Mezhirich, Mezin, Molodove and others.

A close-up of the right-hand end of the engraved mammoth tusk fragment from Kiev-Kirillovskaya (National Museum of History of Ukraine, Kyiv).

The Mezin composite (left) and wide (right) bracelets, which are considered as the paleo-astronomical calendars (National Science Museum of Natural History in Kyiv (left), National Museum of History of Ukraine in Kyiv (right)).
The first Slavic tribes have appeared during the 1st Millennium B.C. At the Ukrainian territory there are two most studied Slavic cultures: Zarubinetska culture and Chernyakhiv culture (II - V centuries).

(left) Vessel-calendar from Romashky (Kyiv region).
(right) The pattern was correctly interpreted by Prof. B. Rybakov as an agriculture calendar from May 2 to August 7 (day of young shoots and holiday of harvesting), this period is just a season of maturing of wheat in Kyiv region.

The ancient vessels (Trypillya culture, IV–II Millennium B.C.) with the astronomical symbolic
ASTRONOMY IN UKRAINE. ORIGINS
Ostroh Academy, 1576

Lviv University Observatory, 1769

Kyiv-Mohyla Academy, 1783
ASTRONOMY AS THE NATURAL PHILOSOPHY AT THE FIRST UNIVERSITIES

• The first astronomical observations and their writing records are dated to the times of Kievan Rus’ (X-XIII centuries). For example, the authors of the Lавrentievsky chronicle described the solar eclipses of 1064, 1091, 1115, and 1230 years and the lunar eclipses of 1161 year as well as the first authentic Comet Galley observation at the Kievan Rus’ territory in 1066.

• In 1483 the first printed book on astronomy was written by physician and astronomer Georgii Drohobich (1450-1494), who was a well-known author of Ukrainian origin.

• Systematic learning in astronomy is connected with the activity of the first Ukrainian universities in the XVII-XVIII centuries, namely the Ostroh Academy (A. Rymsha (1550-1595), astronomical cabinet in 1617-1630), the L’viv University (astronomical observatory in 1769) as well as the Kyiv-Mohyla Academy (astronomical cabinet in 1783).

Андрій Римша. “Хронологія”

Месяца сенебра, по-гебрейску єлюль, просто вресьень,
Двадцять четвертого дня месяца сенебра
dороблен Єросолим, сталася реч добра.
  Месяца октюбрія, по-гебрейску тышри, просто паздерник,
  Арха з Ноїм на горе станула на суши,
  другій потоп не буде, так нам писмо туши.
  Октюбрія 17 дня.
Месяца ноембрія, по-гебрейску маргусам, просто грудень.
Жидом свято уставил тут царь Єровоам,
мы о свої не дбаєм, не велми ж добро нам.
  Ноембрія 15 дня.
Месяца декабрія, по-гебрейску хашель, просто просинець 1.
  В том месяцы Ісус Христос народился нам,

Astronomy as the Natural Philosophy at the Kyiv-Mohyla Academy

• A graduate of the Kyiv-Mohyla Academy, Ivan Kopievsky (1651-1714), issued the first stellar map in the Slavic language in Amsterdam in 1699 and the basics of naval astronomy in 1701.

• The prominent Ukrainian-Russian philosopher, scientist and religious figure, Pheophan Prokopovich (1681-1736), who worked at the Kyiv-Mohyla Academy in 1705 – 1716 (he was the rector of this academy in 1711 – 1716), lectured astronomical courses based on theories of Copernicus and Galileo. He also developed the philosophical foundation of the unity of matter and motion, which was generalized later on by Mikhail Lomonosov.

• The prominent Ukrainian philosopher, scientist and religious figure Irynei (Ivan Falkovsky (1762-1823))

Ph. Prokopovych

Світ… не є нескінченним, але замкненим та обмеженим певними границями…

Передусім, треба знати, що рух із часом має дуже тісний зв'язок так, що ніщо не рухається інакше як у часі і ніщо не вимірюється часом, якщо не рухається…

Матерію не можна ніколи створити, ані зруйнівати, також ні збільшити, ні зменшити ту, яку створив Бог на початку світу, і якою і в якій кількості створена, такою залишається досі й буде залишатися завжди…
ASTRONOMY AS THE NATURAL PHILOSOPHY
AT THE KYIV-MOHYLA ACADEMIA

I. Falkovsky

“Скорочення змішаної математики” (ліворуч)
“Задача з обчислення затемнення Місяця” (праворуч)

Київський Місяцеслов на 1799 р. (ліворуч) і 1800 р. (праворуч)
ASTRONOMY IN UKRAINE
XIX CENTURY
Scientific research in astronomy was started in the XVIIIth century with establishment of University astronomical observatories in L’viv, Odesa, Kyiv, Kharkiv.

In 1821 the Naval Observatory was founded in Mykolaiv (later on as a department of the Pulkovo Observatory).

New impetus for development of astronomical research were connected with the foundation of institutions of the Russian Academy of Sciences (later on the USSR Academy of Sciences) and the All-Ukrainian Academy of Science (later on the UkrSSR AS, and the NAS of Ukraine).
MYKOLAIV NAVAL OBSERVATORY, 1821
KHARKIV ASTRONOMICAL OBSERVATORY, 1824
ODESA ASTRONOMICAL OBSERVATORY, 1871
ASTRONOMY IN UKRAINE
XX CENTURY
Ukraine is a well-known astronomical country in Europe

- Main Astronomical Observatory (Kyiv 1944)
- Crimean Astrophysical Observatory (Simeiz 1908; Naukove 1945)
- Institute of Radio Astronomy (Kharkiv 1950-ies)
- Mykolaiv Astronomical Observatory (1821)
- Astronomical Observatory Kyiv Nat. University (1845)
- Astronomical Observatory L'viv Nat. University
- Astronomical Observatory Odesa Nat. University (1871)
- Institute of Astronomy Kharkiv Nat. University
- ICAMER (p. Terskol, North Caucasus, RF, 1970-ies)
- Space research Laboratory Uzhgorod Nat. Univ., 1957
POLTAVA GRAVIMETRICAL OBSERVATORY, 1926
MAIN ASTRONOMICAL OBSERVATORY, 1944
CRIMEAN ASTROPHYSICAL OBSERVATORY, 1944 (USSR), 1991 (UKRAINE)
RADIO-ASTRONOMICAL OBSERVATORY, 1985
TERSKOL ASTRONOMICAL OBSERVATORY, 1977
STATUS OF ASTRONOMICAL RESEARCH AND EDUCATION ACTIVITY
## Status of astronomical research institutions before 2014

<table>
<thead>
<tr>
<th>Institutions</th>
<th>Number of Scientists</th>
<th>Number of Cand. Sci.</th>
<th>Number of Dr. Sci.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institutions of the National Academy of Sciences of Ukraine (NASU)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main Astronomical Observatory of NASU</td>
<td>102</td>
<td>52</td>
<td>20</td>
</tr>
<tr>
<td><a href="http://www.mao.kiev.ua">www.mao.kiev.ua</a></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institute of Radio Astronomy of NASU</td>
<td>168</td>
<td>55</td>
<td>17</td>
</tr>
<tr>
<td><a href="http://www.ri.kharkov.ua">www.ri.kharkov.ua</a></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory of Astrophysics and Cosmology of Bogolyubov</td>
<td>6</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Institute of Theoretical Physics of NASU</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>International Center for Astronomical, Medical, and Ecological Research of NASU</td>
<td>20</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Institutions of the Ministry for Education and Science of Ukraine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRI &quot;Crimean Astrophysical Observatory&quot;</td>
<td>86</td>
<td>33</td>
<td>16</td>
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<tr>
<td><a href="http://www.crao.crimea.ua">www.crao.crimea.ua</a></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Astronomical Observatory of Taras Shevchenko National University of Kyiv</td>
<td>26</td>
<td>19</td>
<td>6</td>
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<tr>
<td><a href="http://www.univ.astro.kiev.ua">www.univ.astro.kiev.ua</a></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Astronomical Observatory of I.Franko National University of L'viv</td>
<td>22</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>SRI “Astronomical Observatory” of I.I. Mechnikov National University of Odessa</td>
<td>61</td>
<td>14</td>
<td>5</td>
</tr>
</tbody>
</table>
### Status of astronomical research institutions before 2014

<table>
<thead>
<tr>
<th>Institution</th>
<th>Doctoral Students</th>
<th>Master Students</th>
<th>Bachelors Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR Institute of Astronomy of V.N. Karazin National University of Kharkiv</td>
<td>32</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td><a href="http://ru.astron.kharkov.ua/">http://ru.astron.kharkov.ua/</a></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRI “Nikolaev Astronomical Observatory”</td>
<td>15</td>
<td>8</td>
<td>1</td>
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<tr>
<td><a href="http://www.nao.nikolaev.ua/">http://www.nao.nikolaev.ua/</a></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory of Space Researches of the Uzhgorod National University</td>
<td>12</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td><a href="http://www.univ.uzhgorod.ua/static/ndi/pndl/">http://www.univ.uzhgorod.ua/static/ndi/pndl/</a></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Department of High and Applied Mathematics, Odessa National Maritime University</td>
<td>7</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td><a href="http://www.osmu.odessa.ua/application/page?name=vpm">http://www.osmu.odessa.ua/application/page?name=vpm</a></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Department of Astronomy and Space Physics, Taras Shevchenko National University of Kyiv</td>
<td>21</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Department of Astrophysics of I. Franko National University of L'viv</td>
<td>10</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Department of Astronomy of I.I. Mechnikov National University of Odessa</td>
<td>8 (7)</td>
<td>4</td>
<td>2 (1)</td>
</tr>
<tr>
<td><a href="http://onu.edu.ua/uk/structure/faculty/phys/astronomy">http://onu.edu.ua/uk/structure/faculty/phys/astronomy</a></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Department of Astronomy of V.N. Karazin National University of Kharkiv</td>
<td>8 (3)</td>
<td>4 (1)</td>
<td>3 (0)</td>
</tr>
<tr>
<td>Astronomical Institutions of the NAS of Ukraine</td>
<td>296</td>
<td>119</td>
<td>39</td>
</tr>
<tr>
<td>Astronomical Institutions of the Ministry for Education and Science of Ukraine</td>
<td>302</td>
<td>117</td>
<td>42</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>598</strong></td>
<td><strong>236</strong></td>
<td><strong>81</strong></td>
</tr>
</tbody>
</table>

* Post-graduated students are not included in this table
<table>
<thead>
<tr>
<th>Institutions of the NASU (National Academy of Sciences of Ukraine) or MESU (Ministry of Education and Science of Ukraine)</th>
<th>Number of Scientists</th>
<th>Number of Cand. Sci.</th>
<th>Number of Dr. Sci.</th>
<th>Research Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Astronomical Observatory of the NASU <a href="http://www.mao.kiev.ua">www.mao.kiev.ua</a></td>
<td>92</td>
<td>50</td>
<td>12</td>
<td>Space Geodynamics; Positional Astronomy; Astrophysics: Solar System Bodies, Sun, Stars; Extragalactic Astronomy; High-energy Astrophysics; Ground-based and Space-born Instrumentation</td>
</tr>
<tr>
<td>Institute of Radio Astronomy of the NASU <a href="http://www.ri.kharkov.ua">www.ri.kharkov.ua</a></td>
<td>168</td>
<td>55</td>
<td>17</td>
<td>Radio Astronomy (all types of celestial bodies) and Radio Physics; Ground-based Instrumentation</td>
</tr>
<tr>
<td>**SRI &quot;Crimean Astrophysical Observatory&quot; of the Taras Shevchenko National University of the MESU <a href="http://www.crao.crimea.ua">www.crao.crimea.ua</a></td>
<td>69</td>
<td>36</td>
<td>10</td>
<td>Astrophysics: Solar System Bodies, Sun, Stars, Extragalactic Astronomy; High-energy Astrophysics; Radio Astronomy (cm-waves); Ground-based and Space-born Instrumentation</td>
</tr>
<tr>
<td>Institute of Astronomy of V.N. Karazin National University of Kharkiv, MESU <a href="http://www.astron.kharkov.ua">www.astron.kharkov.ua</a></td>
<td>38</td>
<td>15</td>
<td>7</td>
<td>Positional Astronomy; Astrophysics: Solar System Bodies, Sun, Extragalactic Astronomy</td>
</tr>
<tr>
<td>Astronomical Observatory of the Taras Shevchenko National University of Kyiv, MESU, <a href="http://www.observ.univ.kiev.ua">www.observ.univ.kiev.ua</a></td>
<td>31</td>
<td>28</td>
<td>6</td>
<td>Positional Astronomy; Astrophysics: Solar System Bodies, Sun, Stars, Extragalactic Astronomy; Cosmology; High-energy Astrophysics;</td>
</tr>
<tr>
<td>Astronomical Observatory of Ivan Franko National University of Lviv, MESU <a href="http://astro.lnu.edu.ua">astro.lnu.edu.ua</a></td>
<td>21</td>
<td>6</td>
<td>2</td>
<td>Positional Astronomy; Astrophysics: Sun, Stars, Extragalactic Astronomy, high-energy astrophysics; Cosmology;</td>
</tr>
</tbody>
</table>
## Current status of astronomical research institutions

<table>
<thead>
<tr>
<th>Institutions of the NASU (National Academy of Sciences of Ukraine) or MESU (Ministry of Education and Science of Ukraine)</th>
<th>Number of Scientists</th>
<th>Number of Cand. Sci.</th>
<th>Number of Dr. Sci.</th>
<th>Research Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Center for Astronomical, Medical, and Ecological Research of the NASU <a href="http://www.terskol.com">www.terskol.com</a></td>
<td>20</td>
<td>8</td>
<td>1</td>
<td>Optical Observational Astronomy</td>
</tr>
<tr>
<td>SRI “Mykolaiv Astronomical Observatory” , MESU <a href="http://www.mao.nikolaev.ua">www.mao.nikolaev.ua</a></td>
<td>15</td>
<td>4</td>
<td>1</td>
<td>Positional Astronomy; Ground-based Instrumentation</td>
</tr>
<tr>
<td>Laboratory of Astrophysics and Cosmology of Bogolyubov Institute of Theoretical Physics of NASU <a href="http://bitp.kiev.ua/en/department/aep">http://bitp.kiev.ua/en/department/aep</a></td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>quantum field theory and its applications to particle physics, gravity theory and condensed matter physics</td>
</tr>
<tr>
<td>Laboratory of Physical Electronics and Space Research Laboratory of the Uzhgorod National University <a href="https://www.uzhnu.edu.ua/en/cat/deps-lab_space">https://www.uzhnu.edu.ua/en/cat/deps-lab_space</a></td>
<td>12</td>
<td>3</td>
<td>0</td>
<td>monitoring of satellites</td>
</tr>
<tr>
<td>Department of Astronomy and Space Physics, Taras Shevchenko National University of Kyiv <a href="http://space.univ.kiev.ua/en/">http://space.univ.kiev.ua/en/</a></td>
<td>11</td>
<td>4</td>
<td>2</td>
<td>Ionospheric researches</td>
</tr>
</tbody>
</table>
### Current status of astronomical research institutions

<table>
<thead>
<tr>
<th>Institutions of the NASU (National Academy of Sciences of Ukraine) or MESU (Ministry of Education and Science of Ukraine)</th>
<th>Number of Scientists</th>
<th>Number of Cand. Sci.</th>
<th>Number of Dr. Sci.</th>
<th>Research Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Astronomy of V.N. Karazin National University of Kharkiv, <a href="http://www.physics.karazin.ua/en/chairs/k_a.html">http://www.physics.karazin.ua/en/chairs/k_a.html</a></td>
<td>11</td>
<td>5</td>
<td>5</td>
<td>physical conditions at the Moon and Solar System Bodies</td>
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<tr>
<td>Radio Astronomy Research Laboratory named BL Kashcheev of Kharkiv National University of Radio Electronics, <a href="http://nure.ua/branch/naukovo-doslidna-laboratoriya-radioastronomiyi-geofiziki-tadstantsiyogo-zonduvannya-im-b-l-kashcheyeva">http://nure.ua/branch/naukovo-doslidna-laboratoriya-radioastronomiyi-geofiziki-tadstantsiyogo-zonduvannya-im-b-l-kashcheyeva</a></td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>Interpretation of meteor radar observation data together with data about Solar system small bodies, astroinformatics (meteor data bases)</td>
</tr>
</tbody>
</table>
ASTRONOMY
SCIENTIFIC SCHOOLS
OF UKRAINE
IN XX CENTURY
A number of well-known astronomical achievements is connected with activities of so-called “scientific schools”, namely founded by Alexander Ya. Orlov, Nikolai P. Barabashov, Grigory A. Shajn, Vladimir P. Tsesevich, Sergei K. Vsekhsvyatsky, Andrei B. Severny, Semen Ya. Braude and others.
A.YA. ORLOV (1880 — 1954)
ASTROMETRY AND ASTROGEODYNAMICS

1926 : Founder and first director of the Poltava Gravimetical Observatory

1944 : Founder and first director of the Main Astronomical Observatory
RESEARCH FIELDS:

• Positional astronomy
• Rotation of the Earth
• Geodesy and gravimetry
FOLLOWERS OF THIS SCHOOL

Z.N. Aksentyeva

Ye. P. Fedorov
Рух полюса Землі в системі Орлова
Ground-based programmes
Positional Astronomy
Planets around L-dwarfs with Astrometry

Participants:
Switzerland: Geneva Observatory, Drs. J. Sahlmann, D. Segransan, D. Queloz, M. Mayor, S. Udry
Ukraine: Main Astronomical Observatory of NASU, Dr. P. Lazorenko
Spain: CSIC-INTA, Dr. E. Martin

Objective is to study of the possibility extrasolar planets existence around ultracool dwarfs.
Using FORS2/VLT optical imaging for high precision astrometry the search for planets and substellar objects around ultracool dwarfs is undertaken to investigate their multiplicity properties for very low companion masses.

Astrometric measurements were made with an accuracy of two tenths of a milli-arcsecond over two years that reveal orbital motion of the nearby L1.5 dwarf DENIS-P J082303.1-491201 located at 20.77±0.08 pc caused by an unseen companion that revolves about its host on an eccentric orbit in 246.4±1.4 days.
S.K. VSEKHHSVYATSKY (1905 – 1984)
PHYSICS OF COMETS
SPACE PHYSICS

1939 - 1981:
Chair of the
Astronomy
departament of
the Kyiv
University
FOLLOWERS OF THIS SCHOOL

L.M. Shulman     K.I. Churyumov        P.P. Korsun

and others
RESEARCH FIELDS:

• Physics and Chemistry of Comets
• The Origin of the Solar System
V.P. TSESEVICH (1907 — 1983)
PHYSICS OF VARIABLE STARS

1933 — 1937 : Director of the Astronomical Observatory in Dushanbe (Tadzhic Republik)

1944 — 1983 : Director of the Astronomical Observatory of the Odesa University
FOLLOWERS OF THIS SCHOOL

V.G.Karetnikov
I.B.Pustyl’nik
N.S.Komarov
O.F. Pugach

S.M. Andrievsky
T.V.Mishenina
I.L. Andronov
V.V.Kovtyukh
Research fields:

- Variable stars of different types
- Chemical and dynamic evolution of stars and galaxies

N.P. BARABASHOV (1894 — 1971)
PHYSICS OF MOON AND PLANETS

1930 — 1971: Director of the Astronomical Observatory of the Kharkiv University
FOLLOWERS OF THIS SCHOOL

I.K. Koval          O.V. Morozhenko          I.N. Belskaya          Yu.G. Shkuratov
and others
Ground-based programmes
Solar Systems Bodies & Exoplanets

PROGRAM OF PHOTOMETRIC OBSERVATIONS OF NEAR-EARTH AND SMALL MAIN-BELT ASTEROIDS

70-cm telescope at Abastumani  1.5-m telescope at Maidanak  2-m telescope at Rozhen

PROGRAM OF PHOTOMETRIC OBSERVATIONS OF NEAR-EARTH AND SMALL MAIN-BELT ASTEROIDS

70-cm telescope near Kharkiv  1-m telescope at Simeiz  70-cm telescope at Lisyky
G.A. Shajn (1892 — 1956)

1944 : Founder and first director of the Crimea Astrophysical Observatory

A.B. Severny (1913 — 1987)

Observational astrophysics
Solar physics

1952 — 1987 : Director of the Crimea Astrophysical Observatory
RESEARCH FIELDS:

• Stellar spectroscopy
• Solar activity and oscillations
• Space research
FOLLOWERS OF THIS SCHOOL IN UKRAINE
SOLAR PHYSICS

• T.T. Tsap
• E.A. Gurtovenko
• P.R. Romanchuk
• R.I. Kostyk
• N.G. Shchukina
• S.M. Osipov
• V.G. Lozitsky
Досягнення геліофізиків ГАО НАНУ
2016

Сонячний телескоп Ернеста Гуртовенка
Моніторинг довгострокових змін сонячних спектральних ліній на телескопі Гуртовенка

Отримані результати – ключ до розуміння природи активності Сонця та її взаємозв'язку зі станом міжпланетного середовища та екосистем Землі.

Сонячний телескоп Ернеста Гуртовенка (вид всередині)

- Сонячний телескоп Ернеста Гуртовенка по своїй спектральній роздільній здатності входить до трійки найпотужніших телескопів світу.
- У відділі фізики Сонця розроблені унікальні технології обробки спектральних спостережень Сонця
SUN MAGNETIC FIELD
Виявив спостережні свідчення існування у сонячних спалахах екстремально сильних магнітних полів напруженістю 20-90 кГс.

Основний аргумент на користь таких полів – поява достовірного розщеплення емісійних піків у спектральних лініях з дуже малими і емпірично визначеними факторами Ланде (близько 0.01) у п’яти потужних сонячних спалахах.

Спостережене розщеплення емісійних піків
в лінії FeI 5434.5 Å \( (g_{\text{eff}} = -0.014) \) у винятково потужному сонячному спалаху 28.10.2003 балу X17.2 / 4B.

S.YA. BRAUDE (1911 — 2003)  
RADIOASTRONOMY

1958 : Founder of the Radioastronomical Observatory at Grakove village near Kharkiv city

1985 : Founder of the Radioastronomical Institute of the NASU
RESEARCH FIELDS:

• Radiophysics

• Low frequency radioastronomy
FOLLOWERS OF THIS SCHOOL

O.O. Konovalenko

A.V. Men’
Ukraine possesses of unique interferometer system URAN (Fig.2) The distribution of the radio astronomy means on the Ukraine territory is following: Radio telescopes UTR-2, URAN-1, URAN-4 belong to IRA NASU; URAN-2 and URAN-3 belong to Poltava Gravimetric Observatory of NASU respectively. Ukrainian instruments are actively using in the international collaboration with France, Austria, Germany, the Netherlands, India, Japan, Russia, Belgium, Great Britain. Ukrainian radio astronomers are involving officially in the international radio astronomy Projects for various topics (The Sun, space weather, Saturn, interplanetary medium, interstellar medium, pulsars, active stars, exoplanets, etc.).
Three types of astronomy programs could be considered:

- of international level
- of national level
- of institutional level

There are the space-based and grand-based programs.
GROUND-BASED ASTRONOMICAL PROGRAMMES
• Positional Astronomy
• Solar Physics
• Solar System Bodies & Exoplanets
• Physics of Stars and Galaxies
• Extragalactic Astronomy
• e-Astronomy, GRID & Data Network
GROUND-BASED PROGRAMMES
POSITIONAL ASTRONOMY
INTERNATIONAL CELESTIAL REFERENCE FRAME

Participants:

- **USA:** NASA Goddard Space Flight Center
- **Ukraine:** Main Astronomical Observatory NASU, Dr. Ya. Yatskiv; Crimean Astrophysical Observatory MESU, Dr. A. Volvach
- and others

Objective is to upgrade the ICRF2 and construct the ICRF3.
VLBI is a geometric technique: it measures the time difference between the arrival at two Earth-based antennas of a radio wavefront emitted by a distant quasar. Using large numbers of time difference measurements from many quasars observed with a global network of antennas, VLBI determines the Inertial Reference Frame defined by the quasars and simultaneously the precise positions of the antennas.
Ground-based programmes
Positional Astronomy
International Celestial Reference Frame

IVS Network
### General characteristics of CRF solutions

<table>
<thead>
<tr>
<th>Name of catalogue</th>
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</table>
Ground-based programmes
Positional Astronomy
International Celestial Reference Frame

Second Realization of the International Celestial Reference Frame (ICRF2)

- Image shows the 295 defining sources of the ICRF2 on the celestial sphere
- ICRF2 contains precise positions of 3414 compact extragalactic radio sources
- Sources are typically quasars - very distant extragalactic radio sources
- ICRF2, adopted at the 2009 IAU General Assembly, effective since 1 January 2010 (replaced ICRF1)
GROUND-BASED PROGRAMMES
POSITIONAL ASTRONOMY
OPEN STAR CLUSTERS IN THE MILKY WAY

Participants:

**Germany:** Astronomisches Rechen-Institut, Zentrum für Astronomie der Universität Heidelberg, Dr. S. Roeser, Dr. E. Schilbach; Leibniz-Institut für Astrophysik Potsdam, Dr. R.-D. Scholz

**Russia:** Institute of Astronomy of RAS, Prof. A.E. Piskunov

**Ukraine:** Main Astronomical Observatory of NASU, Dr. N.V. Kharchenko

Objective of the project is to use stellar clusters as tracers of the evolution of the Milky Way and to estimate their contribution to the stellar content of the Galaxy at every stage of a clusters' life up to a few tens kpc. Using new deep, all-sky surveys (f.e. 2MASS, SDSS, PPMXL), we will carry out the largest, most complete, homogeneous and comprehensive photometric and kinematic census of stellar clusters and associations to data.
Results

• Up to now the largest input list of 3784 targets from the literature was compiled and confirmed that 3006 are real objects: stellar associations, open and globular clusters. For each confirmed object we determined the exact position of the cluster centre, the apparent size, proper motion, distance, color excess, tidal radius and age. For about 1500 clusters, these basic astrophysical parameters have been determined for the first time.

• Based on uniformly determined cluster parameters (kinematics, age, distance, tidal radius, mass, luminosity function, metallicity), we will derive the cluster dispersal rate and explore what governs it, along with the star formation history of the Galaxy as traced by clusters.
Ground-based programmes
Positional Astronomy
Open star clusters in the Milky Way
Objective is to study of the possibility extrasolar planets existence around ultracool dwarfs.
Using FORS2/VLT optical imaging for high precision astrometry the search for planets and substellar objects around ultracool dwarfs is undertaken to investigate their multiplicity properties for very low companion masses.

Astrometric measurements were made with an accuracy of two tenths of a milli-arcsecond over two years that reveal orbital motion of the nearby L1.5 dwarf DENIS-P J082303.1-491201 located at $20.77\pm 0.08$ pc caused by an unseen companion that revolves about its host on an eccentric orbit in $246.4 \pm 1.4$ days.
GROUND-BASED PROGRAMMES
SOLAR PHYSICS

MAGNETISMO SOLAR Y ESPECTROPOLARIMETRIA EN ASTROFISICA (2004-2006)
MAGNETISM AND POLARIZATION IN ASTROPHYSICS (2007-2009)

Participant's:

Spain: Instituto de Astrofísica de Canarias, Drs. H. Socas Navarro, J. Trujillo Bueno et al.; CAB, Dr. J. Cernicharo
Ukraine: Main Astronomical Observatory of NASU, Dr. N.G. Shchukina
Switzerland: Istituto Solari Ricerche, Drs. M. Bianda, R. Ramelli
USA: NCAR, Drs. R. Casini, R. Centeno, B.W. Lites; NSO, Dr. H. Uitenbroek; Univ. Kentucky, Dr. M. Elitzur; Univ. Alabama, Dr. K. Kobayashi
Sweden: Univ. Stockholm, Dr. J. de la Cruz
Italy: Univ. Florencia, Dr. E. Landi Degl'Innocenti
France: THEMIS, Dr. A. López Ariste
Japan: NAOJ, Dr. S. Tsuneta

Objectives are to explore in depth the physics and origin of polarized radiation in astrophysical plasmas as well as its diagnostic use for understanding cosmic magnetic fields, with emphasis on the magnetism of the extended solar atmosphere.
The longitudinal Zeeman effect and the Hanle diagnostics were used to find small-scale magnetic fields in the quiet solar photosphere. The results of Hanle diagnostics indicated that the bulk of the quiet solar photosphere is significantly magnetized, due to the ubiquitous presence of an unresolved magnetic field with an average strength $<B> \approx 130$ G.
Objective is the study of the diverse manifestations of the magnetic field in the solar atmosphere and in other stars. These include distinct structures as sunspots, weak quiet-sun fields or chromospheric and coronal features such as filaments and prominences.
The observations at the German Vacuum Tower Telescope (Observatorio del Teide, Tenerife, Spain) using two different instruments: the Triple Etalon SOLar Spectrometer (TESOS) were made to measure velocity and intensity variations along the photosphere in the Ba II 4554 Å line; and, simultaneously, the Tenerife Infrared Polarimeter (TIP-II) to the measure Stokes parameters and the magnetic field strength at the lower photosphere in the Fe I 1.56 μm lines. The convective velocities of granules in the facular area decrease with magnetic field while the convective velocities of intergranular lanes increase with the field strength. The strong magnetic field of the facular area seems to stabilize the convection and to promote more effective energy transfer in the upper layers of the solar atmosphere, since the convective elements reach greater heights.

The panels from left to right are: Ba II 4554E continuum intensity in units of its spatially averaged value; mask applied to locate granules and intergranular lanes; Ba II 4554E line center intensity in units of its spatially averaged value; magnetic field strength in units from the inversion of Fe I IR lines. Contours mark the location of granular areas with the magnetic field above 1.2 kG.
STUDY OF PHYSICAL PROPERTIES OF TRANSNEPTUNIAN OBJECTS AND CENTAURS


- the main goal is to study surface properties by different techniques (the polarimetry team is headed by I. Belskaya) and provide essential information about the conditions in the early Solar System environment at large distances from the Sun.

- observations at 8 m telescope (VLT) to provide good-quality data for faint objects (20-22 mag) using FORS, ISAAC and SINFONI instruments; ~400 h of observing time in the service mode were granted since 2007.
GROUND-BASED PROGRAMMES
SOLAR SYSTEMS BODIES & EXOPLANETS

MAIN RESULTS

• The first taxonomy of transneptunian objects.
• Number of relationships between physical and dynamical properties of TNOs
  needed to test and improve the models of Solar system origin and evolution.
• Detailed information on the composition and surface texture of all large bodies
  (D>1000 km) discovered so far beyond Neptune.

PROGRAM OF PHOTOMETRIC OBSERVATIONS OF NEAR-EARTH AND SMALL MAIN-BELT ASTEROIDS IN INSTITUTE OF ASTRONOMY OF KARAZIN KHARKIV NATIONAL UNIVERSITY

- Searching for binary asteroids and determining parameters of the binary systems: In cooperation with Czech astronomers from Ondrejov Astronomical Observatory, Czech Academy of Sciences. More than 20 binary asteroids have been detected and/or investigated.
- Detection of Yarkovsky-O'Keeffe-Radzievskii-Paddack effect (YORP effect) for an asteroid as a result of photometric observations: In cooperation with Czech astronomers from Institute of Astronomy of Charles University in Prague. Three of four asteroids with detected to date YORP effect have been discovered (Apollo, Geographos, Eger).

In Ukraine the coordinated photometric observations in frame of the program have been carried out with the 70-cm telescope at Kharkiv Observatory, the 1-m telescope at Simeiz Observatory, and the 70-cm telescope at Lisnyky Observatory. Additional observations have been made in cooperation with Abastumani Observatory (Georgia) on the 70-cm and 1.25-m telescopes, with Maidanak Observatory (Uzbekistan) on the 60-cm and 1.5-m telescopes, with Rozhen Observatory on the 2-m telescope. All of these telescopes have been equipped with modern CCD-cameras.
Ground-based programmes
Solar Systems Bodies & Exoplanets

PROGRAM OF PHOTOMETRIC OBSERVATIONS OF NEAR-EARTH AND SMALL MAIN-BELT ASTEROIDS

70-cm telescope near Kharkiv
1-m telescope at Simeiz
70-cm telescope at Lisnyky

PROGRAM OF PHOTOMETRIC OBSERVATIONS OF NEAR-EARTH AND SMALL MAIN-BELT ASTEROIDS

70-cm telescope at Abastumani
1.5-m telescope at Maidanak
2-m telescope at Rozhen
Collaboration between Lviv AO and Shanghai AO (China)

International cooperation between Lviv Astronomical Observatory and Shanghai Observatory of Chinese Academy of Sciences started in 2010.

In 2011 Lviv AO received the CCD Camera from ShAO for the satellites observations. Especially the Chinese colleagues were interested in the satellite carried by the Russian cosmic mission Fobos-Grunt. The results of observations (light curves) were sent to ShAO (Dr. Z.H. Tang).
GROUND-BASED PROGRAMMES
PHYSICS OF STARS

Rocky Planets Around Cool Stars (ROPACS)
FP7 Marie Curie Actions - Networks for Initial Training (ITN)
Grant Agreement Number 213646, PITN-GA-2008-213646.

Participants:

United Kingdom: University of Hertfordshire;
University of Cambridge

Spain: Instituto de Astrofísica de Canarias;
Instituto Nacional de Tecnica Aeroespacial

Germany: Max-Planck-Gesellschaft zur Foerderung der Wissenschaften

Ukraine: Main Astronomical Observatory of NASU, Dr. Ya.V. Pavlenko
The network’s objectives are the following:

- To carry out observational programmes to place constraints on transiting systems, using measurements of the primary and secondary eclipses.

- To develop a theory observational techniques to study the properties of cool stars and cool star systems, and study how these properties relate to the presence (or not) of orbiting extra-solar planets.

Main goals of the MAO’s node: to develop cool star atmospheric models; to measure spectroscopy of cool star hosts over a broad/useful spectral range; to fit cool star properties with models, and assess the implications for orbiting planets.
The effective temperature and metallicity of the CM Draconis binary components were determined. CM Dra is the benchmark object for the theory of cool dwarfs formation and evolution. It is a double-lined eclipsing binary system which consists of two M dwarfs. In our analysis we used 29 echelle spectra from the archive of the 4.2-m William Herschel Telescope. The spectra were obtained at high-resolution spectrograph (UES) in different phases. We fitted our calculated synthetic spectra of the CM Dra system as a whole to the observed spectra at all phases. The effective temperature $T_{\text{ef}}=3220 \pm 55$ K and metallicity $[\text{M/H}]=-0.47 \pm 0.25$ were obtained for both components of CM Dra from analysis of the best fit parameters for the spectral regions containing strong enough atomic absorption lines, i.e. NaI 8185 Å, NaI 8197 Å, Rbl 7818 Å and FeI 8077 Å.
The analysis of WTS-1b and WTS-2b, namely two first extrasolar planets found by the WFCAM Transit Survey from observations at the 3.8-m United Kingdom Infrared Telescope (UKIRT) in 2007 August, was carried out. Planets were discovered by analysis of light curves comprising almost 1200 epochs with a photometric precision of better than 1% to $J \sim 16$ were constructed for $\sim 60,000$ stars and searched for periodic transit signals. For one of the most promising transiting candidates, high-resolution spectra taken at the Hobby-Eberly Telescope (HET) allowed us to estimate the spectroscopic parameters of the host star, a late-F main-sequence dwarf ($V = 16.13$) with possibly slightly subsolar metallicity, and measure its radial velocity variations. The combined analysis of the light curves and spectroscopic data resulted in an orbital period of the substellar companion of 3.35 d, a planetary mass of $4.01 \pm 0.35$ MJ and a planetary radius of $1.49 - 0.18 + 0.16$ RJ. WTS-1b has one of the largest radius anomalies among the known hot Jupiters in the mass range 3-5 MJ. The high irradiation from the host star ranks the planet in the pM class. Based on observations collected at the 3.8-m United Kingdom Infrared Telescope (Hawaii, USA), the Hobby-Eberly Telescope (Texas, USA), the 2.5-m Isaac Newton Telescope (La Palma, Spain), the William Herschel Telescope (La Palma, Spain), the German-Spanish Astronomical Centre (Calar Alto, Spain), the Kitt Peak National Observatory (Arizona, USA) and the Hertfordshire's Bayfordbury Observatory.
GROUND-BASED PROGRAMMES
PHYSICS OF STARS

EVOLVED STARS: CLUES TO THE CHEMICAL EVOLUTION OF
GALAXIES (POSTAGBINGALAXIES)

FP7 Marie Curie Actions - People International Research Staff Exchange Scheme.
Grant Agreement Number 269193, PIRSES-GA-2010-269193.

Participants:

Latvia: Latvijas Universitate
Poland: Nicolaus Copernicus Astronomical Centre of the Polish AS
Ukraine: Main Astronomical Observatory of NASU
China: Yunnan Astronomical Observatory of Chinese AS
United States: The Lutheran University Assoc., Inc.
Russia: Institute of Astronomy of the RAS

Objectives: (1) the pulsation and dynamical phenomena in the (outer) atmospheres, (2) the structure and mass-loss history, (3) the chemistry and the kinematics of the outflows.
Objectives for MAO NASU

1. Observation of cool R CrB stars at 2.6 m Crimean and 2.0 m Terskol telescopes, data reduction and interpretation.

2. Self-consistent analysis of spectra of R CrB stars using computed model atmospheres, taking account of molecular and atomic opacities. Model atmospheres will be computed for the abundances obtained by our analysis. Fits to the low-resolution spectra will be used to determine the basic parameters. Process of abundance and basic parameters determinations will be repeated iteratively till the convergence of the model.

3. Fits of computed spectra to the observed fluxes in the optical and infrared spectral regions. Determination of the temporal changes of the main physical parameters.

4. Evolutionary changes of abundances in atmospheres of R CrB stars. Validation of existing theories of evolution of R CrB stars; are they genuine post-AGB stars or binary mergers.
GROUND-BASED PROGRAMMES
PHYSICS OF STARS
EVOLVED STARS: CLUES TO THE CHEMICAL EVOLUTION OF GALAXIES
(POSTAGBINGALAXIES)

Study of post-ABG-stars.
R CrB stars. Fits to SEDs of SV Sge.

Li in the evolved stars. Fits to Li resonance doublet in WZ Cas spectrum.
GROUND-BASED PROGRAMMES
PHYSICS OF STARS

The Synchronous Network of distant Telescopes

Participants:

Ukraine: Main Astronomical Observatory of NASU,
Dr. B. Zhilyaev, O. Svyatogorov, I. Verlyuk

Russia, Ukraine: International Centre for Astronomical, Medical and
Ecological Research, peak Terskol, Kabardino-Balkaria,
Dr. A. Sergeev, M. Andreev

Ukraine: Crimean Astrophysical Observatory of MESU,
M. Lovkaya

Bulgaria: Institute of Astronomy and Rozhen NAO; Space Research Institute
of Bulgarian AS; Institute of Mathematics and Informatics,
Dr. S. Antov, R. Konstantinova-Antova, R. Bogdanovski

Greece: University of Thessaloniki
S. Avgoloupis, J. Seiradakis, M. Contadakis
The Synchronous Network of distant Telescopes (SNT) represents an innovative approach in observational astrophysics. All the telescopes of the Network are equipped with standardized photometric systems (based on photomultipliers). The unified timing systems (based on GPS-receivers) synchronize all the apertures to UTC with an accuracy of 1 microsecond and better. The essential parts of the SNT are the original software for operating and data processing.

Described international Network successfully works for more than 10 years. The obtained unique observational data made it possible to discover new fine-scale features and flare-triggered phenomena in flaring red dwarfs.
Ground-Based Programmes

Physics of Stars

The Synchronous Network of Distant Telescopes

Transient processes in stars

The SNT allows us to discover brightness oscillations during flares of stars. These oscillations allow to diagnose plasma of stellar coronae. Oscillations in flares are caused by magneto-acoustic waves in coronal loops of stars. Such a flare oscillation provides an excellent opportunity to obtain coronal properties like the size of a flare loop or the local magnetic field strength.

Fast colorimetry of the flare star allowed estimating the temperature at maximum brightness and its size.

Two-site photometry of a flare on EV Lac, 2004 September 16, as seen simultaneously by telescopes sited in Ukraine (points) and Greece (solid).

UBV colorimetry of a flare on EV Lac. The temperature near flare peaks amounts to ~ 18500 K. The size of flare area amounts to ~ 1.1% of the apparent stellar disk.
CCD photometry of a faint cataclysmic variable stars and relative objects in the Crimean astrophysical observatory.
Photometry of the cataclysmic variables in the Crimean astrophysical observatory in 1975 – 2012 years with 38-cm, 50-cm, 1.25-m and in the primary focus of the 2.6-m Shajn mirror telescope.

The most significant results:

Discovery of the non-linear spin-orbital synchronization in the asynchronous polar V1500 Cyg, finding of the observational evidences of the complex magnetic field structure in the asynchronous polar BY Cam; finding of a strong dependence of its accretion geometry on the magnetic field orientation;

Discovery of the 2006 outburst in the dwarf nova EZ Lyn, its identification, discovery of the 12.6-min nonradial pulsations of the accreting white dwarf and their evolution, discovery of the brown dwarf counterpart in this binary;

Discovery of the nodal precession of accretion disk in the dwarf nova MN Dra

Discovery of the optical counterpart to the black hole in the X-ray nova J0422+32;

Classification of the ROSAT sources 1RXS J184542+483134, 1RXS J003828.7+250920 and 1RXS J105120.5+672550.

The light curve of cataclysmic variable EZ Lyn (=SDSS J0804) in 2006—2011. Intervals of the first detection of the nonradial WD pulsations, stable and non-stable their behavior are marked.
Ground-based programmes
Physics of Stars

"Stars, Stellar Explosions, and the Origin of the Elements"


Switzerland: Departement Physik, Universität Basel
(F. K. Thielemann);
Observatoire de Genève, Université de Genève
(C. Charbonnel);

Ukraine: Astronomical Observatory, Odesa National University,
Odesa (T.V. Mishenina).

The run of [Sr/Fe] with [Fe/H] in the Galaxy

Observations were made at 1.93 m telescope of the observatory OHP (France).
“Galactic evolution of the chemical elements”

USA: Department of Astronomy, Case Western Reserve University, Cleveland, (R.E.Luck); University of Washington (G.Wallerstein); University of Hawai’i (R.P.Martin);
Brazil: Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, (J. R. D. Lipine, et. all);
France: GEPI, Observatoire de Paris (M. Spite, M., F. Spite F., et. all); Université Côte d’Azur (V.Hill);
Ukraine: Astronomical Observatory, Odesa National University (S.M.Andrievsky, et. all).

[Diagram: 
[Cu/Fe] vs. [Fe/H]
]
“Milky Way metallicity gradient from Classical Cepheids. Chemical evolution of Galaxy”

USA: G.Wallerstein, R.E.Luck, P. Martin


Germany: B.Lemasle

Italy: G.Bono

South Africa: A. Knyazev

Ukraine: Astronomical Observatory, Odesa National University, Odesa (S.M.Andrievsky, V.V.Kovtyukh)
International collaboration of Lviv Astronomical Observatory

Collaboration with Geneva Cosmology Group (Department of Theoretical Physics, University of Geneva) on observational constraints on cosmological models with different types of dark matter and dark energy (e.g. scalar fields with barotropic equation of state) and new cosmological tests.

- Cooperation with Astronomical Observatory of the Jagiellonian University (Cracow, Poland) on artefacts in the CMB maps and Gamma-ray bursts as cosmological probes.
Ground-based programmes
Cosmology and Gravity theories

International collaboration of Odesa Astronomical Observatory
with

CERN (Switzerland), North Carolina Central University (USA),
University of Cologne (Germany),
INAF - Osservatorio Astronomico di Bologna (Italy), University
of the Basque Country UPV/EHU (Spain),
Universidade da Beira Interior (Portugal), Charles
University (Czech Republic),
Jilin University (China), Istanbul Technical University (Turkey).

Main topics:
Large scale structures of the Universe, gravitational
interaction in the Universe, dark matter and dark energy,
alternative gravitational theories

The results of researches are published in journals: PhLB,
EPJC, PhRvD, IJMPh, PDU, and others.
High performance, massively parallel, direct N-body simulations of galaxy center with black holes on GPU clusters across Europe.

MAO, Kiev, Ukraine:
Peter Berczik, Alexander Veles, Igor Zinchenko...

ARI, Heidelberg, Germany:
Rainer Spurzem, Andreas Just, Eva Grebel
+ more PhD students & postdocs under new SFB 881.

+ strong collaboration with NAOC, Beijing, China.

Galaxy Collisions $\sim$ BH’s collisions
Ground-based programmes

e-Astronomy, GRID & Data Network

Galaxy Collisions $\approx$ BH’s collisions
Objectives of GEO-AN:

1. Arranging for studies and model development on:
   a) Sun’s invariability on various time scales;
   b) Interplanetary space processes;
   c) Earth’s magnetosphere and ionosphere;
   d) Atmosphere-ocean interaction;
   e) Solid Earth’s phenomena, including seismicity and geodynamics.

2. Creating data acquisition and data support systems in field of geosciences.

3. Assessing implementation of the GMES and GEOSS action plans in Ukraine.
Sun is our star e.i. stormy star. There are many well-known Solar phenomena observed by ground- and space-based techniques. Some of these phenomena are interrelated. It is necessary to understand,

How Sun’s outbursts affect our home planet?
Earth Watch.

Continuous observation and monitoring of the Earth’s land, atmosphere, ocean and ice caps for: Study such phenomena as El Niño, ozone “hole”, greenhouse effect, etc.; Study of the interactions between the cloud, radioactive and aerosol processes that play a role in climate regulation; others related to Space Environment Domains.
NASU APPLIED ASTRONOMY & SPACE SCIENCE PROGRAMMES
STUDY OF THE GEO-SPACE PHENOMENA

Space Science
Space Weather
Space Debris
Space Hazard
NASU APPLIED ASTRONOMY & SPACE SCIENCE PROGRAMS
STUDY OF THE GEO-SPACE PHENOMENA
METEO - MAGNETIC DATA PROCESSING

Number of Cyclones - N = 260; Observation Interval - 1996-2006; Average time delay - $t_N = 30-40$ min; Average period $T_N = 70-90$ min
NASU Applied Astronomy & Space Science programmes
Study of the GEO-SPACE phenomena (2009-2011)
**NASU Applied Astronomy & Space Science programmes**  
**Study of the GEO-SPACE phenomena (2009-2011)**

### Space Debris

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<td>Diff.</td>
</tr>
<tr>
<td>SV</td>
<td>~ 2 000</td>
<td>Diff.</td>
</tr>
<tr>
<td>SF</td>
<td>~ 10 000</td>
<td>&gt;20 cm</td>
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OBSERVATIONAL SERVICES
(ASTRONOMY & RELATED SCIENCES)

- International Earth Rotation Service (IERS)
- Space Geodesy Services (SGS)
  ILRS, IVS, IGS, DORIS

Participants: more than 100 observational services (20 in Ukraine)

Objectives: Definition and realization of coordinate systems and frames; determination of the Earth Rotation Parameters; study of global geodynamics
Earth’s time-variable data on

- Shape
- Gravity field
- Rotation

The shape of planet Earth

SLR network of Ukraine

<table>
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<tr>
<th>Name</th>
<th>Domes</th>
<th>Started In</th>
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<td>12368S001</td>
<td>1998</td>
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OBSERVATIONAL SERVICES (ASTRONOMY & RELATED SCIENCES)

Ukrainian Permanent GNSS Network (2012)
OBSERVATIONAL SERVICES
(ASTRONOMY & RELATED SCIENCES)

VLBI station of Ukraine

Name of station: Simeiz (Crimea) VLBI station
IERS DOME NUMBER: 123375008
EQUIPMENT: Radiotelescope RT-22
Mark-5A and Mark-5B+
recording systems
H-maser for time and frequency

The radiotelescope RT-22 has a steering parabolic mirror with diameter 22 m and focal length 9525 mm. The surface has a root mean square accuracy 0.25 mm and effective area 210 m² which does not depend on elevation angle at frequencies 2.3 and 8.4 GHz. The antenna has an azimuth-elevation mounting with axis offset -1.8 ± 0.2 mm. Working range in azimuth is [-210°, 210°] (zero is to the south) and in elevation [-1°, 85°]. Maximum slewing rate is 1°.5/sec. The control system of the telescope provides accuracy of pointing at the level of 10".
Observational Services
(Astronomy & related Sciences)

IS UKRAINE ABLE TO MEET NEW CHALLENGES FOR INTERNATIONAL SPACE GEODESY SERVICES?

Coordinates and velocities of VLBI stations

The “Simeiz-Katsiveli” space geodynamics co-location site
(Black Sea area to west of Yalta city)
# Observational Services (Astronomy & related Sciences)

**UMOS (Ukrainian network of optical stations)**

<table>
<thead>
<tr>
<th>UMOS</th>
<th>Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiev</td>
<td>Main Astronomical Observatory</td>
</tr>
<tr>
<td>Nikolav</td>
<td>RI &quot;Nikolaev Astronomical Observatory&quot;</td>
</tr>
<tr>
<td>Odessa</td>
<td>Astronomical Observatory of Odessa National University</td>
</tr>
<tr>
<td>Lviv</td>
<td>Astronomical Observatory of Lviv National University</td>
</tr>
<tr>
<td>Uzhgorod</td>
<td>Space Research Laboratory of Uzhgorod National University</td>
</tr>
<tr>
<td>Alchevsk</td>
<td>State interuniversity center of satellites laser ranging observations &quot;Orion&quot;</td>
</tr>
<tr>
<td>Evpatoria</td>
<td>National Space Center</td>
</tr>
<tr>
<td>Dunaevcy</td>
<td>Center of the Special Information Receiving and Processing and the Navigation Field Control</td>
</tr>
</tbody>
</table>
Observational Services (Astronomy & related Sciences)

UMOS (Ukrainian network of optical stations)

UMOS Activities

- Modernization / automation of old telescopes
- Manufacturing of new telescopes
- Development of original observation techniques
- Development of observation and processing software
- Angular observations of satellites on all orbit types
- Photometry observations of satellites on low orbit
- Development of software for orbit calculation and catalogue maintaining
- Development of software for analysis of tumbling behavior and shape
Angular observations

**Observed object types:**
- Low Earth orbit (LEO) satellites down to mini satellite size
- LEO space micro satellites and debris ≥ 0.1 m size
- Geostationary Earth orbit (GEO) space debris ≥ 1 m size
- Middle Earth orbit satellites (MEO) ≥ 2 m size
- High Elliptical orbit satellites

**Goals:**
- Orbit calculation:
  - maintaining of own orbit catalogue
  - calculation of close approaches distances

**Photometry observations**

**Most observed objects:**
- Topex, Envisat, Jason, EgyptSat, Sich-2, Midas

**Goals:**
- Determination of tumbling periods:
  - stabilization
  - secular variations
- Comparing of observed light curve with modeled one:
  - orientation
  - structural health
- Classification of light curves:
  - shape type (sphere, cube, plane ...)

Mechanical tracking technique

- **Lens:** $F = 3000$ mm, $D = 500$ mm
- **Camera:** TV CCD
- **LEO observations:**
  - limited magnitude: 11 mag
  - angular random/systematic error: 0.5/0.5 arcsec
- **feature:** parallel photometry observations

Electronically tracking technique

- **Lens:** $F = 3000$ mm, $D = 500$ mm
- **Camera:** full frame CCD + rotator
- **LEO observations:**
  - limited magnitude: 14 mag
  - angular random/systematic error: 0.6/1.4 arcsec
- **MEO, GEO observations:**
  - limited magnitude: 16 mag
  - angular random/systematic error: 0.3/0.7 arcsec
Objective: in order to remain at the proper place of world astronomy, Ukraine must ensure new technological developments for providing the necessary platforms for new instruments and facilities.

Radio Astronomy

Ukraine is leading country in field of decametric radioastronomy thanks to activity by Prof. S.Ya. Braude and his followers. Ukraine possesses of world largest decameter wavelength (frequencies are 8-32 MHz) radio telescope UTR-2.

Fig.1. The UTR-2 radio telescope, N-S arm (1.8 km x 60 m) \( f = 8...32 \text{ MHz} \) \( A_{\text{eff max}} = 150 000 \text{ sq.m} \)
Ukraine possesses a unique interferometer system URAN (Fig.2). The distribution of the radio astronomy means on the Ukraine territory is as follows: Radio telescopes UTR-2, URAN-1, URAN-4 belong to IRA NASU; URAN-2 and URAN-3 belong to Poltava Gravimetric Observatory of NASU respectively.

Ukrainian instruments are actively used in the international collaboration with France, Austria, Germany, the Netherlands, India, Japan, Russia, Belgium, Great Britain. Ukrainian radio astronomers are involved officially in the international radio astronomy projects for various topics (The Sun, space weather, Saturn, interplanetary medium, interstellar medium, pulsars, active stars, exoplanets, etc.).
Many priority astrophysical results and discoveries were obtained by the implementation of these instruments due to the best sensitivity; spatial, frequency and temporal resolution; dynamic range; informatively; and efficiency. One result connected with the high sensitive dynamic range and interference immune observations of the interplanetary ionosphere scintillations (in the frame of the space weather problems) by using UTR-2 is presented on Fig. 3a (see also another results in this slide).
Astronomy technological programmes

Radio Astronomy

• The European radio community is actively testing the new technology for decameter radio interferometer LOFAR. Therefore, Special Program of NASU for the deep modernization and upgrade of the world largest UTR-2 radio telescope is adopted. It includes, in part, the development and installation of the new generation high dynamic range super multichannel digital spectrum analyzes.

• Furthermore it is very important the creation of new generation low frequency additional radio telescope on the UTR-2 observatory, it is GURT (Giant Ukrainian Radio Telescope). This new radio telescope has broader band (10-80 MHz), high sensitivity, dynamic range and efficiency.

• This activity is supporting by the international PICS Project (Ukraine-France) “Development of low frequency radio astronomy with ultra-high sensitivity and resolution”. Ukrainian radio astronomers give strong contribution to the creation of the low-frequency LSS (LOFAR Super Station) radio telescope in France and to the development of the world low-frequency radio astronomy in whole.
Telescope with a mirror diameter 1 m. Installed in Slovakia. Jointly operated by Astronomical Observatory of Odessa National University (Ukraine) and Vihorlat Astronomical Observatory (Slovakia). Vihorlat Observatory is a new one. It is situated at the Kolonice Sedlo in the north-east of Slovakia. Observatory coordinates: latitude = 48° 57' N, longitude = 22° 16' E. Altitude is 465 m above sea level.

Telescope characteristics: Argunov – Faschevskyi optical system, focal length is 9 m. The Cassegrain focus of the telescope is equipped with the high-speed two-star photometer, which was constructed in Astronomical Observatory of Odessa National University.

The main observational programs are focused on the study of eclipsing binaries, cataclysmic and symbiotic stars, stars of RR Lyr and BY Dra types.
A new automatic telescope, a 800-millimeter main mirror catadioptic anastigmatic aplanat, is mounted at Mayaki station in suburb of Odesa. It is equipped with a focal corrector and a professional CCD camera.
SPACE-BASED ASTRONOMICAL PROGRAMMES
• Previous projects (with Ukrainian contribution)

\textbf{Solar Physics:} CORONAS-I, CORONAS-F, CORONAS-Foton,
\textbf{Space Physics:} INTERBALL, ISS
\textbf{Radioastronomy:} RadioAstron

• On-going projects (with Ukrainian contribution)

\textbf{Solar System Body Physics:} ExoMars, GAIA, UNO

• Future projects (Ukrainian-led and contribution)

\textbf{Space Physics:} IONOSAT-Micro (2019); IONOSAT (2021), Aerosol-UA (2022)
\textbf{Astrophysics:} BRAUDE-M (?)
Ground – Space radio interferometer Program “RadioAstron”
( wavelengths is 1.35 – 92 cm; D max is 350 000 km; Ang.res. is 10 microarcsec)
SPACE-BASED PROGRAMMES: RADIOASTRON

- RT-70 radio telescope (Evpatoria, Ukraine, National Space Center of SSAU) as the ground segment of this mission was prepared and upgraded by Institute of Radio Astronomy NASU for this mission since 2011. The interferometric responses were detected for many radio sources, base-lines, and frequency ranges.
Space-based programmes: RadioAstron

Radio interferometric response for the base RT-70 – SRT-10 (50 000 km)

Детектирование интерферометрического отклика на рекordo большой базе 50 000 км RT-70 (Евпатория) – KRT-10 (КА “Спектр-Р”)

Фурье-преобразование интерферометрического отклика

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<th>Диапазон волн</th>
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<tr>
<td>Радиоисточник</td>
<td>Активная галактика BL Lacerte</td>
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<tr>
<td>Расстояние между антенами (база)</td>
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<tr>
<td>Угловое разрешение</td>
<td>240 мкс дуги</td>
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</tbody>
</table>
Polarimetry of Mars with Hubble Telescope
Astronomical Institute of Kharkov National University, Ukraine

A new type of Martian clouds seen in UV range with HST polarimeter was discovered (see arrows in figure). The clouds consist of small water crystals.

Космічний проект CORONAS - DIFOS

Геліосейсмологія

CORONAS-I: 16.03.1994 - 07.05.1994

За допомогою приладу DIFOS проведено космічні спостереження глобальних коливань яскравості Сонця в п'яти довжинах хвиль на орбітальних станціях КОРОНАС-І & КОРОНАС-Ф

Е. Гуртовенко, Л. Кесельман, Р. Костик, С. Осипов
Вперше виявлені аномалії 5-хвилинних коливань яскравості та швидкості. Гравітаційні моди коливань Сонця не знайдені.

Поверхня Сонця коливається з різними періодами. Найпотужніші коливання (акустичні) відбуваються з періодом ≈ 5 хвилин. Амплітуда яскравості − 10⁻⁵ яскравості центру диска Сонця.
• Spectacular astronomic results have been obtained in Europe through a large range of space missions (e.g. Cassini, XMM, Cluster, Mars-Express, SOHO, Kepler, Venus-Express, Hershel, Planck).

  Ukraine didn’t participated in these mission. Some teams of the Ukrainian astronomers access data collected by these space missions.

• A relevant Ukrainian participation has been in Russian–led space missions up to 2014 (e.g. ISS, FOBOS, RadioAstron).

• It is specially important, given the current world space activity, to prepare national astronomical space projects (e.g. UkrSelena and BRAUDE-M)
UKRAINIAN ASTRONOMICAL ASSOCIATION
UAA was founded in 1991 and since this year the UAA coordinates the astronomical activity in Ukraine.

The UAA consists of 15 Institutional Members & dozens of Individual Members.

The UAA is served as the National Committee of astronomers in Ukraine. There are more than 1500 persons in Ukraine involved in astronomical researches.
Links with Government:

Expert's opinion on Projects of

the National Academy of Sciences of Ukraine

the Ministry of Industrial Policy

the Ministry for Education and Science

Interbranch scientific & engineering technology Projects

Publicly funded observatory:

Ahdrushivka observatory
The most important national universities which have astronomy and space related faculties:

Shevchenko National University of Kyiv
V.N. Karazin National University of Kharkiv
I.I. Mechnikov National University of Odesa
Ivan Franko National University of L’viv
National Technical University “Kyiv Polytechnical Institute”
National University of Dnipropetrovsk
V.I. Vernadsky Taurian National University in Simferopol
National University of Uzhgorod
Zhukovsky National Aerospace University in Kharkiv

- 80% of the entering students finish their education in 5 years
- 50% of students, who finished their education, continue to work in astronomy
- 30% of holders of a Specialist’s diploma or Master’s Degree defend a Candidate Thesis within 3 - 7 years after they graduate
From 2016 the MES of Ukraine has merged the specialties of physics and astronomy into common one - 104 "Physics and Astronomy".
У КНУ освітня програма «Астрономія» дозволяє набирати студентів в бакалавратуру окремо від освітньої програми «Фізика». Ліцензійний обсяг підготовки бакалаврів за цією програмою – 25 осіб. МОН щороку виділяє 8 – 12 бюджетних місць, що корелює з кількістю заяв абітурієнтів в попередній рік, переважно заяв з 1-м пріоритетом. За правилами МОН кількість бюджетних місць в магістрантурі складає 50% від випуску бакалаврів поточного року. Всі, хто не втрапить на бюджет, можуть іти на контракт (близько 32 тис.грн за рік). Останні декілька років з’явилася нова тенденція – виїзд на магістерські програми за кордон, раніше їхали переважно в аспірантуру.

В ОНУ не оформлено вступ на спеціальність 104 за окремими навчальними планами, тому студенти протягом навчання можуть обирати фізику або астрономію.

У 2016 та 2017 роках на фізичний факультет ЛНУ здійснювався набір на спеціальність 104 без поділу на спеціалізації. З 2018 р. студенти можуть обрати спеціалізацію "Теоретична фізика та астрофізика". Очікується, що як мінімум половина з них будуть орієнтовані на астрономію.
SOME PROBLEMS OF HIGH SCHOOL

• There is slow degreasing of the number of student in astronomy from 75 (in 2002) to about 50 (at present).

• One of the problem is passing the External independent testing (EIT) for physics resulted from low level of teaching the physics in school.

• MES of Ukraine has established a limit of the number of student for special groups (not less then 10). In case of astronomy it is not appropriate. Adequate number is 3 - 5.

• Astronomical textbook and teaching facilitate have to be approved.
## SECONDARY SCHOOL

<table>
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<th>Subject</th>
<th>PHYSICS</th>
<th>Subject</th>
<th>ASTRONOMY</th>
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<td><strong>Hours/Week</strong></td>
<td><strong>Class</strong></td>
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<td>2</td>
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<tr>
<td>9</td>
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<td>3</td>
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<tr>
<td><strong>Secondary education of 3(^{rd}) degree</strong></td>
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<td></td>
<td><strong>Secondary education of 3(^{rd}) degree</strong></td>
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<tr>
<td>10</td>
<td>3 (Standard level - STL)</td>
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<td>6 (Specific level - SPL)</td>
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<td>2 (STL)</td>
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<td>11</td>
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<td></td>
<td>3 (Academic level - AL)</td>
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<td>0.5 (AL)</td>
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<td>6 (SPL)</td>
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</tr>
</tbody>
</table>
ПРОБЛЕМИ СЕРЕДНЬОЇ ШКОЛИ

Школи, за винятком 40-50 фіз.-мат. ліцеїв по всій Україні, випускають учнів, які не здатні осилити університетські курси фізики і математики. В суспільстві створена стійка відраза до науки взагалі і точних наук зокрема. Зменшення потоку абітурієнтів призводить до автоматичного зменшення кількості ставок викладачів в університетах.

В школах працюють, за невеликою кількістю винятків, вчорашні трієчники, кращі випускники шкіл не йдуть в педагогічні університети вже впродовж більше 30 років. Вчителі самі дуже приблизно знають матеріал, який викладають. Більшість вчителів фізики не здатні розв'язувати стандартні задачі з фізики.
У переліку спеціалізацій спеціальності 014 "Середня освіта" (підготовка вчителів для шкіл) відсутня Астрономія. За її відсутності у назві спеціалізації 014.08 ЗВО мають повне право ігнорувати астрономічні курси та спецкурси, а тому багато майбутніх вчителів фізики просто не знатимуть астрономію.
Publications

- Information Bulletin of the Ukrainian Astronomical Association
- Astronomical Calendar (annual)
- Odesa Astronomical Calendar (annual)
- Scoolar Astronomical Calendar (annual)
- Textbooks of astronomy for students:
  - Celestial Mechanics, Physics of Planetary atmospheres, Solar physics,
- Magazines: Svitoglyad ("World view"), Vselennaya, Prostranstvo, Vremya ("Universe .Space. Time."")
- Books on History of Astronomy
Science funding is worse

Beginning in 1991, the total expenditure (budgetary and off-budgetary) for research and development (R&D) has been reduced by a factor of 4 (750 000 000 USD in 2004). The gross expenditure on R&D as a percentage of GDP also has been reduced by a factor of two. The total budgetary expenditure on science and technology (S&T) in 1991 – 2002 in relative terms of purchasing-power parity has also deteriorated by one-half to 2 030 000 USD in 2002 (Yatskiv 2004).

Science in Ukraine, including astronomical research, is now facing a difficult time due to economic limitations of the nation and the need for upgrading the existing scientific infrastructure. The key problems are both the low GDP activities and the fact that even the low budgetary expenditures on science and technology have not been effectively spent. In 2005 the adopted budget is 20 400 000 000 USD with 5% devoted to R&D.

Prestige

The need to raise the prestige of the scientific profession irrespective of the low salaries for young scientists and engineers.

Secondary astronomical education

How to increase the number of new textbooks?
How to organize regular training of astronomy teachers?
Thank you for your attention!