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Determining the Galactic bar parameters based on the Hercules and Wolf 630 stellar streams

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Abstract. We identified the four most significant features in the UV velocity distribution of solar neighborhood stars: H1, H2 and W1, W2 in the Hercules and Wolf 630 streams, respectively. We set the task of determining a number of characteristics of the central Galactic bar independently by analyzing each of the identified features under the assumption that the Hercules and Wolf 630 streams have a bar-induced dynamical nature. We solve the problem by constructing 2 : 1 resonant orbits in the rotating bar frame for each star in these streams. Our analysis of the resonant orbits found has shown that the bar pattern speed Ω_b lies within the range 45–52 km s⁻¹ kpc⁻¹ with a mean of 48.1 ± 1.0 km s⁻¹ kpc⁻¹, while the bar angle θ_b is within the range 35°–65° with a mean of $50 \pm 4^\circ$. The results obtained are consistent with the view that the Hercules and Wolf 630 streams could be formed by a single mechanism associated with the fact that a long-term influence of the Galactic bar led to a characteristic bimodal splitting of the UV velocity plane.

Key words: stars: kinematics and dynamics – Galaxy: fundamental parameters – Galaxy: kinematics and dynamics – solar neighborhood – stellar streams: individual (Hercules stream, Wolf 630 stream)

Role of gaseous disk in the formation of the spiral structure of the Milky Way galaxy

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Abstract. We use observational gaseous and stellar density distributions in the disk of the Milky Way (MW) galaxy together with the disk rotation curve and measured disk velocity dispersion to build collisionless and combined collisionless-gaseous equilibrium models of the Milky Way disk. A purely collisionless MW disk is unstable towards the development of a central bar, so that during the nonlinear stage of instability the stellar bar is a dominant non-axisymmetric structure developing the disk. A ten percent admixture of a gaseous component leads to the development of a three-armed spiral structure in the stellar disk, decoupled spatially from the central bar-like structure. In our simulations, the spiral structure lasts for about 3 Gyr.

Key words: ISM: kinematics and dynamics – Galaxy: disk – Galaxy: spiral structure – Galaxy: kinematics and dynamics

Instability of stationary spherical models with orbits arbitrarily close to radial

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Abstract. The classical problem of the stability of stationary stellar spherical models with purely radial motion is reconsidered. The problem is due to strong central singularity in the density distribution, resulting in not entirely rigorous proof made in the well-known Antonov's paper. To avoid this difficulty, we construct a suitable two-parametric series of models with moderately elongated and nearly radial orbits, without singularity, and pass to the limiting case of models with orbits arbitrarily close to purely radial. The stability of the series with respect to odd and even spherical harmonics is considered. The growth rates of aperiodic even modes increase indefinitely when approaching purely radial models.

Key words: galaxies: formation – galaxies: evolution

Unusual objects in the spiral galaxy NGC 6946

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Abstract. Several strange objects in the spiral galaxy NGC 6946 are described. One of these objects is the giant stellar complex noted long ago; we suggested that its sharp semicircular western edge is a result of the ram pressure, arising owing to motion of this complex through the HI halo of NGC 6946. We found another enigmatic object, proposing for it the name Red Ellipse; it is located within the isolated Northern arm of the galaxy. The enormous size of this Ellipse, and especially the spectroscopic data obtained recently with the 6-m reflector of the Special Astrophysical Observatory, made us to conclude that this object could not be a supernova remnant. The excellent image of NGC 6946 obtained with the Subaru 8-m telescope also shows a strange region with several regular crossed dark lanes, connected with a black spot.

Key words: galaxies: individual: NGC 6946 – galaxies: spiral – galaxies: star formation

Properties of stellar streams in the Galactic disk

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Abstract. Stars of the Sirius, Coma Berenices, Hyades, Pleiades, Wolf 630, Dehnen 6, Dehnen 14, HR 1614, η Cephei, γ Leo streams, the newly identified two subgroups of the Hercules stream, and the streams BB 14, BB 17, BB 20, and BB 21 are selected using the components of space velocities from three independent catalogs. The relationship between their ages, metallicities and relative abundances of α -elements are studied. The data of the three catalogs show slightly different properties for each of the streams studied. However, the general tendency shows that the dependences studied for the stars within the streams hardly differ from those found for the field stars with the corresponding velocities. The dependences found confirm the assumption that all of the streams studied could have been formed as a result of resonance effects due to the Galactic bar or spiral density waves acting on field stars.

Key words: Galaxy: disk – Galaxy: stellar content – solar neighborhood: stellar streams

Hidden population of Algols

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Abstract. We present the results of Monte Carlo simulation aiming to estimate the frequency of semi-detached Algol-type binaries among the stars observed as single. When an account is taken of various detection biases (mostly due to inclination of orbits), the fraction of Algols among the Galactic disk stars appears to be 0.1–0.2%. However, this number should be regarded as a lower limit only, since there are still unaccounted-for selection effects and other types of photometrically unresolved binaries. Hidden binarity appears to be an important phenomenon that should be taken into account when considering stellar statistics and constructing the fundamental relations between stellar parameters.

Key words: binaries: eclipsing – binaries: close

On utmost multiplicity of hierarchical stellar systems

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Abstract. According to theoretical considerations, multiplicity of hierarchical stellar systems can reach, depending on masses and orbital parameters, several hundred, while observational data confirm the existence of at most septuple (seven-component) systems. In this study, we cross-match the stellar systems of very high multiplicity (six and more components) in modern catalogues of visual double and multiple stars to find among them the candidates to hierarchical systems. After cross-matching the catalogues of closer binaries (eclipsing, spectroscopic, etc.), some of their components were found to be binary/multiple themselves, what increases the system's degree of multiplicity. Optical pairs, known from literature or filtered by the authors, were flagged and excluded from the statistics. We compiled a list of hierarchical systems with potentially very high multiplicity that contains ten objects. Their multiplicity does not exceed 12, and we discuss a number of ways to explain the lack of extremely high multiplicity systems.

Key words: Stars: binaries: general – binaries: visual

Mathematical problems in creating large astronomical catalogs

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Abstract. The next stage after performing observations and their primary reduction is to transform the set of observations into a catalog. To this end, objects that are irrelevant to the catalog should be excluded from observations and gross errors should be discarded. To transform such a prepared data set into a high-precision catalog, we need to identify and correct systematic errors. Therefore, each object of the survey should be observed several, preferably many, times. The problem formally reduces to solving an overdetermined set of equations. However, in the case of catalogs this system of equations has a very specific form: it is extremely sparse, and its sparseness increases rapidly with the number of objects in the catalog. Such equation systems require special methods for storing data on disks and in RAM, and for the choice of the techniques for their solving. Another specific feature of such systems is their high “stiffness”, which also increases with the volume of a catalog. Special stable mathematical methods should be used in order not to lose precision when solving such systems of equations. We illustrate the problem by the example of photometric star catalogs, although similar problems arise in the case of positional, radial-velocity, and parallax catalogs.

Key words: methods: data analysis – catalogs: photometric

Bar formation in Milky Way type galaxies

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Abstract. Many barred galaxies, possibly including the Milky Way, have cusps in their centers. There is a widespread belief, however, that the usual bar instability, which occurs in bulgeless galaxy models, is impossible for cuspy models because of the presence of the inner Lindblad resonance for any pattern speed. At the same time, there is numerical evidence that the bar instability can form a bar. We analyze this discrepancy by performing accurate and diverse N -body simulations and calculating the normal modes. We show that bar formation in cuspy galaxies can be explained by taking into account the disk thickness. The exponential growth time is moderate (about 250 Myr) for typical current disk masses, but it increases considerably (by a factor of two or more) if the live halo and bulge are substituted by a rigid halo/bulge potential; the pattern speeds remain almost the same. Normal mode analysis with different disk mass favors a young bar hypothesis, according to which the bar instability has saturated only recently.

Key words: galaxy: formation – galaxy: evolution

Visual binary stars: data to investigate formation of binaries

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Abstract. Statistics of orbital parameters of binary stars as well as statistics of their physical characteristics bear traces of star formation history. However, statistical investigations of binaries are complicated by incomplete or missing observational data and by a number of observational selection effects. Visual binaries are the most common type of observed binary stars, with the number of pairs exceeding 130 000. The most complete list of presently known visual binary stars was compiled by cross-matching objects and combining data of the three largest catalogues of visual binaries. This list was supplemented by the data on parallaxes, multicolor photometry, and spectral characteristics taken from other catalogues. This allowed us to compensate partly for the lack of observational data for these objects. The combined data allowed us to check the validity of observational values and to investigate statistics of the orbital and physical parameters of visual binaries. Corrections for incompleteness of observational data are discussed. The datasets obtained, together with modern distributions of binary parameters, will be used to reconstruct the initial distributions and parameters of the function of star formation for binary systems.

Key words: binaries: visual – astronomical databases: miscellaneous – catalogs

Basic kinematics of the Galactic disk from open cluster data

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Abstract. The kinematic parameters of the Galactic disk are redetermined based on open-cluster data. It is shown that the Bottlinger-Oort model of pure circular rotation can be confidently used to describe the observed motions of disk objects at least out to heliocentric distances of 3.5 kpc.

Key words: Galaxy: disk – Galaxy: fundamental parameters – open clusters and associations: general

Radial velocity dispersions of star groups in M 67

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Abstract. High-precision measurements of radial velocities of the M 67 cluster members are used to calculate the radial-velocity dispersions in the stellar groups found earlier in the cluster's corona. The previously detected feature in one of the groups (Group 60) consisting of stars with almost identical space velocities was confirmed. The possibility of more accurate future studies of the parameters of star groups using the *Gaia* catalogues is discussed.

Key words: solar neighborhood – open clusters and associations: individual (M 67)

Search for and investigation of double open clusters

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Abstract. The physical and kinematical parameters of three pairs of open clusters, NGC 6755 and Czernik 39, NGC 1857 and Czernik 20, Berkeley 70 and SAI 47, are determined using the data from several photometric catalogs in order to confirm or disprove the binarity of these pairs.

Key words: open clusters and associations: individual (NGC 6755, Czernik 39, NGC 1857, Czernik 20, Berkeley 70, SAI 47)

Observational data and orbits of the asteroids discovered at the Molėtai observatory in 2008–2009

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Abstract. We present the statistics of the asteroids observed and discovered at the Molėtai Observatory, Lithuania, in 2008–2009 within the project for astrometric observations of the near-Earth objects (NEOs), the main belt asteroids and comets. CCD observations of the asteroids were obtained with the 35/51-cm Maksutov-type meniscus telescope. In the Minor Planet Circulars and the Minor Planet Electronic Circulars (2008–2009), 11 900 astrometric positions of 2522 asteroids were published. Among them 95 were new asteroids, including four belonging to the Trojan group: (352655) 2008QX28, 2008 SE8, (353194) 2009 SM100 and (264068) 2009 SQ148. For the asteroids discovered at Molėtai their precise orbits are calculated. Because of short observational arc, a few asteroids have low-precision orbits and some asteroids are considered lost. For the three Main Belt asteroids with low-precision orbital elements, 2008 QP32, 2008 SD8 and 2008 SG150, we present their ephemerides for 2017. They can be brighter than 20 mag.

Key words: minor planets, asteroids: search, astrometry, orbits