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Survival probability for a hypervelocity star in close neighborhood of a supermassive black hole

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Abstract. We present the results of numerical simulation on the probability of formation of a Hypervelocity Star (HVS) in the scenario of dynamic capture of a close binary system by the central black hole in the Galaxy and on the probability of its survival in the strong tidal field in the vicinity of the black hole. The results have been obtained for a series of pericentric distances. We applied a two-level numerical simulation implemented at first in the framework of the three-body problem used for evaluation of the HVS ejection velocity and then as an N-body approach that allowed us to establish the final status of the star: the degree of its destruction and mass loss. Probability estimations are based on a statistical ensemble of 10 000 initial configurations of the close binary with respect to the orbital phase of the components as well as to the inclination of the binary orbit to the plane of the orbit around the super-massive black hole and on the ensemble of 50 configurations for the three-body and N-body approaches, respectively.

Key words: stars: black holes, binaries, kinematics and dynamics, mass-loss – methods: numerical simulation

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Interstellar matter structure along the line of sight to Cyg X-1

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Abstract. High-resolution spectra of Cyg X-1 = V1357 Cyg obtained with the NES echelle spectrograph of the Russian 6 m telescope (3950–6690 Å) were used to study narrow interstellar absorption lines. We resolved the interstellar line blends by fitting them with Gaussian profiles. The main three absorption components, with the heliocentric radial velocities V_r = –1, –13 and –26 km/s, were revealed. They correspond to three interstellar gas and dust complexes along the line of sight to the object. Thus, we get information on the distribution of interstellar matter along the way to Cyg X-1. The interstellar calcium abundance and ionization degree, averaged along the line of sight, were determined. A weak component with V_r = –43 km/s is revealed in the profiles of the strongest lines. We relate it to the approaching wall of the expanding interstellar envelope around the Cyg OB3 association (superbubble). This finding supports the view that Cyg X-1 was born in this stellar association and is still located in it.

Key words: ISM: structure – ISM: interstellar lines – stars: X-ray binary: Cyg X-1 – stars: V1357 Cyg – stars: optical spectroscopy

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Properties of open clusters in the regions of the Local Bubble and the Eridanus Superbubble

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Abstract. Features of the relative positions of open clusters and two superbubbles in the vicinity of the Sun, the Local Bubble and the Eridanus Superbubble, are considered. It is shown that the open clusters are concentrated toward the neutral gas shell of the Local Bubble, while there is a deficiency of clusters inside the cavity. All clusters associated with the Eridanus Superbubble belong to a compact group at the northern edge of the shell; no clusters are present inside the superbubble. Kinematics, age, and other physical and chemical properties of the clusters are investigated. It is found that the metal-deficient clusters and the clusters with high velocities are absent in the sample considered, i.e., the properties of the clusters associated with the Local Bubble and the Eridanus Superbubble are typical of the thin disk objects of the Galaxy.

Key words: superbubbles: individual (Local Bubble, Eridanus Superbubble) – open clusters: fundamental parameters

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Abundances of chemical elements in open star clusters as indicators of their nature

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Abstract. Applying a compilled catalog, we find that the relative abundances of α-elements in open clusters and in field stars of the thin disk of the Galaxy show different dependencies on metallicity, age and parameters of their Galactic orbits. The distinctions are explained by different nature of open clusters and field stars. We confirm the conclusions, reached earlier from the analysis of the parameters of Galactic orbits, that some clusters may have formed from the impact of metal-poor high-velocity clouds on the interstellar matter of the thin disk. Arguments are also adduced in favor of the formation of metal-rich high-velocity clusters from the interaction of metal-rich intermediate-velocity clouds formed from returning gas of the Galactic "fountain" with the interstellar medium of the thin disk.

Key words: stars: red giants – Galaxy: disk – open clusters: abundances, kinematics

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Fractal properties of the solar neighborhood based on the Geneva-Copenhagen survey

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Abstract. This study analyzes the fractal properties of the space distribution of stars in the solar neighborhood, based on the Geneva-Copenhagen Survey data. We demonstrate the existence of dynamically weakly coupled stochastic fractal structures in the circumsolar stellar medium. The number of such structures in the real stellar medium on 3 to 20 pc scales significantly exceeds the number of similar structures in the corresponding simulated random distributions. The total number of fractal structures depends on their characteristic size – the scale factor (Mf). We demonstrate that the structuredness of the stellar medium increases with the scale factor reaching its maximum around 18 pc and has a minimum around 5 pc. For Mf = 5 pc, the number of fractal structures in the survey is equal to 688, while for Mf = 18–20 pc the corresponding number exceeds 4000, which differs by more than three standard deviations from the mean fractal dimension D for random distributions. Practically, no structures are observed in random distributions in this domain of fractal dimensions. The proportion of fractal structures with [Fe/H] > 0 increases slowly with increasing scale factor and the number of such structures remains in the interval from 170 to 900. On the whole, the number of structures with [Fe/H] < 0 varies with scale factor in the same way as the total number of structures, and lies in the interval from 530 (Mf = 5 pc) to 3200 (Mf = 20 pc). Such significant differences between the fractal properties of the real stellar medium and its random simulations are due to peculiar "gravitational viscosity" of the gravitating medium. The results reported may play an important part in the study of structural properties and dynamic processes in the Galaxy and in the investigation of relaxation processes in particular.

Key words: stars: kinematics and dynamics – stars: fractal structures – solar neighborhood

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Determination of the solar galactocentric distance from the kinematics of masers

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Abstract. We determine the parameters of Galactic rotation and the solar galactocentric distance R_0 by simultaneously solving Bottlinger's kinematic equations using data for masers with known line-of-sight velocities and highly accurate VLBI trigonometric parallaxes and proper motions. Our sample includes 93 masers spanning the range of galactocentric distances R from 3 to 15 kpc. The inferred parameters are $\Omega_0 = 29.7$ km/s kpc, $\Omega_0' = -4.20$ km/s kpc^2, $\Omega_0'' = 0.73$ km/s kpc^3 and $R_0 = 8.03$ kpc, implying a circular rotation velocity of $V_0 = 238 \pm 6$ km/s at the solar distance R_0.

Key words: masers – Galaxy: kinematics and dynamics – Galaxy: solar galactocentric distance

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A new estimate of the Local Standard of Rest from data on young objects

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Abstract. To estimate the peculiar velocity of the Sun with respect to the Local Standard of Rest (LSR), we use young objects in the Solar neighborhood with distance measurement errors within 10%–15%. These objects include the nearest Hipparcos O–B2.5 type stars, masers with VLBI trigonometric parallaxes, and two samples consisting of the youngest and middle-aged cepheids. The most significant component of motion of all these stars is induced by the spiral density wave. An analysis of these samples, taking into account differential Galactic rotation and the effect of the spiral density wave, yields the following components of the vector of the peculiar velocity of the Sun with respect to the LSR: $(U_\odot, V_\odot, W_\odot)_{\rm LSR} = (6.0, 10.6, 6.5)$ km/s. We found the Solar velocity components $(U_\odot)_{\rm LSR}$ and $(V_\odot)_{\rm LSR}$ to be highly sensitive to the Solar radial phase $\chi_\odot$ in the spiral density wave.

Key words: masers – Galaxy: kinematics and dynamics – Galaxy: Local Standard of Rest.

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Distribution and kinematics of classical cepheids in the Galactic outer ring

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Abstract. The existence of an outer ring in the Galaxy can explain the kinematics of OB associations in the Perseus and Sagittarius stellar-gas complexes. Moreover, it can also explain the orientation of the Carina arm with respect to the major axis of the bar. We show that the morphological and kinematical features of the sample of classical cepheids are consistent with the presence of a two-component outer ring in the Galaxy.

Key words: Galaxy: structure: Galaxy: kinematics and dynamics

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The mechanism and timescale of nodal precession: two nuclear stellar disks in the Galactic center

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Abstract. A dynamical model of interacting nuclear stellar rings in the central parsec of our Galaxy is constructed. We discuss the physical sources of nodal precession and of the associated time scales. For approximate study of the mutual orbital precession, we replace broad nuclear rings by weighted average narrow circular rings. The model with narrow circular rings is shown to adequately describe the nodal precession. The period of relativistic apsidal precession in the center of the Galaxy, $\sim 5{\cdot}10^8$ yr, is almost an order of magnitude longer that the period of nodal precession, $\sim 7{\cdot}10^7$ yr, due to gravitational perturbations of nuclear disks (or rings). An important property of the nodal precession of nuclear rings is established: the lines of nodes of the two rings rotate uniformly with the same angular velocity, but in different directions. This explains the important observational fact that the lines of nodes of nuclear disks are not collinear, but are directed at large angles to each other.

Key words: gravitation – methods: analytical – celestial mechanics, stellar dynamics

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Structure and kinematics of polar ring galaxies: new observations and estimation of the dark halo shape

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Abstract. The polar ring galaxies (PRGs) represent an interesting type of peculiar systems in which the outer matter is rotating in the plane which is roughly perpendicular to the disk of the main galaxy. Despite the long-lasting study of the PRGs, the amount of observational data detailed enough is insufficient; there still remain many open questions. Among the most interesting issues, there are: estimating the flattening of dark matter halos in these systems and verifying the assumption that the most massive polar structures were formed by accretion of the matter from intergalactic filaments. The new catalog recently compiled by our team using SDSS images increased, by several times, the number of known PRGs. The current paper gives an overview of our latest results on the study of morphological and photometric structure of the PRGs. Using the stellar and ionized gas kinematics data based on spectroscopic observations with the Russian 6-m telescope, we estimate the shape of dark matter halo in individual galaxies.

Key words: galaxies: peculiar – galaxies: kinematics and dynamics – galaxies: evolution, structure

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Solving stellar astronomy problems in the orbital stellar stereoscopic observatory project

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Abstract. We propose to establish an Orbital Stellar Stereoscopic Observatory consisting of two identically equipped spacecrafts in the vicinity of two Lagrangian libration points, $L4$ and $L5$, of the "Sun – Earth + Moon barycenter" system. The stereoscopic baseline length is $B \approx 259.111$ million km (86.4% of the Earth orbit diameter). Each of the two Tsukanova-Korsch three-mirror astrographs has an aperture of 1 m and focal length of 30 m; the focal-plane CCD array is 350 mm in diameter. The expected astrometric accuracy is $\pm$ 0.0007 arcsec in a single measurement. Each frame in the scientific program is captured synchronously by the two astrographs, allowing to obtain instantaneous parallaxes of stars as far as up to 5 kpc, along with spectral energy distributions (SEDs) of point and extended sources in the Tholen filter system (Zellner et al. 1985) extended to 12–14 bands, including the integral one. We expect the project to provide a large amount of important information for stellar astronomy and for various studies of Galactic objects.

Key words: space vehicles: instruments – stars: distances – Galaxy: kinematics and dynamics

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The possibility of a deep scanning survey of part of the sky from a low-orbit spacecraft with fixed orbital orientation

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Abstract. We analyze the possibility of performing a deep survey of a part of the sky near the poles of the spacecraft orbit from a low-orbit spacecraft with fixed orbital orientation. The survey depth can be increased by several magnitudes by reducing the surveyed sky area to strips along one or two minor circles at constant declination. The surveyed area is scanned by precession of the spacecraft.

Key words: all-sky survey – deep survey – scanning observations – photometry – orbital orientation

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The first light of Mini-MegaTORTORA wide-field monitoring system

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Abstract. We describe the first light of a new 9-channel wide-field optical monitoring system with sub-second temporal resolution, Mini-MegaTORTORA, which is being tested now at the Special Astrophysical Observatory in Russian Caucasus. The system is able to observe the sky simultaneously in either wide ($\sim$900 deg^2) or narrow ($\sim$100 deg^2) fields of view, either in clear light or with any combination of color (Johnson B, V or R) and polarimetric filters installed, with exposure times ranging from 100 ms to 100 s. The primary goal of the system is the detection of rapid (with sub-second characteristic time scales) optical transients, but it may be also used for studying variability of sky objects over longer time scales.

Key words: instrumentation: photometers – methods: observational – techniques: photometric

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UBVJHKLM photometry and low-resolution spectroscopy of Nova Delphini 2013 (V339 Del)

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Abstract. We present UBVJHKLM photometric observations of Nova Delphini 2013 that started several hours before maximum light and lasted for 130 nights. Using the obtained data, we derived several photometric parameters of the Nova: the time of maximum light, brightness at maximum, rate of decline, $t_2 = 11$ d. This places Nova Del 2013 among fast novae according to the classification introduced by Payne-Gaposchkin. We estimated the interstellar reddening E(B-V) = 0.18 using maps of Galactic extinction and the absolute brightness in maximum light via the MMRD relation that allowed us to determine the distance $D \approx 2.7$ kpc and height above the Galactic plane $z \approx 440$ pc. Low-resolution spectroscopy shows that Nova Del 2013 belongs to the Fe II spectral type of novae. The broad emission feature near 6825 Å observed during 2013 August and September may be the Raman-scattered O VI 1032 Å line.

Key words: novae – infrared: stars – stars: individual: V339 Del