COMPILED CATALOGUE OF THE MK SPECTRAL CLASSIFICATIONS, INCLUDING ASTROMETRIC AND PHOTOMETRIC DATA AND ITS APPLICATION

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The catalogue constructed as a tool for stellar kinematic analysis is described. It contains up-to-date information on spectral classifications in the MK system, positions and proper motions in the ICRS system, as well as BV magnitudes for 169 843 single stars. Astrometry and photometry were mainly selected from the Tycho-2. MK spectral types and luminosity classes were combined after revision of 11 original spectral catalogues, available from CDS. The first results of stellar kinematic analysis based on compiled catalogue are presented.

INTRODUCTION

As is well recognized, the Hipparcos catalogue, provided the best quality proper motions and parallaxes in the ICRS system, offers completely new possibilities for investigation of local galactic kinematics. Up to now, there has been one of the most complicated kinematic problem associated with determination of galactic rotation from proper motions referred to rotation frame. Since the Hipparcos catalogue has been constructed in a frame with negligible rotation with respect to inertial one, it is possible, for the first time, to solve perfectly such a problem. Indeed, uses of the Hipparcos data have already given considerable insight into the galactic rotation problem as well as into the kinematic properties of local stellar populations. Moreover, newly released extensive catalogues of high quality proper motions in the Hipparcos system can also be used for this purpose. The Tycho-2 is the largest among them. Recall that this all-sky catalogue contains proper motions and homogeneous two-colour photometry for about 2.5 million stars. Consequently, the aim of the study presented here is to combine high quality proper motions with astrophysic data into common catalogue in order to revise kinematics of stars in the vicinity of the Sun. To compose the catalogue we have chosen the Tycho-2 as the main source of proper motions and BV magnitudes for our compilation of known spectral classifications in the MK system, is available from the CDS in Strasbourg. So, we attempted to built the compiled catalogue in such a way to include the largest possible number of stars. The resulting catalogue of about 170 000 stars has been used to redetermine the kinematic properties of main sequence stars and cool giants as a function of their spectra.

COMPILED CATALOGUE

In order to construct the compiled catalogue eleven spectral catalogues of the MK classifications were selected from the CDS database. The main selection criteria were the follows: possibility of star identification in astrometric catalogues and large comprehension of sources. As a result, all selected spectral catalogues contain about 250 000 single stars in total. They combine MK spectral classifications from a wide variety of literature sources, published in 1964–1999.

Searching for common stars was based on comparison of their coordinates (right ascension and declination) from initial spectral catalogues. The coordinates were preliminary transformed to the same equinox (J2000.0) and then they were sorted in right ascension order. Such a procedure allows to identify common objects in effective manner. A search radius was adopted in the range of 0.5–1.5 arcminutes due to poor accuracy of positions in spectral catalogues. The procedure was repeated a few times with increasing separation distance and with excluding the identified stars. HD numbers or stellar magnitudes were additionally used for position matches in unreliable cases. The resulting catalogue has no multiple entries for the same star. Data for every star were extracted from a certain source catalogue in accordance with its priority assigned at the highest level to the most recent source. The compiled list was then extended by including additional Hipparcos stars with known MK classifications. Accurate positions, proper motions, and two-colour photometry in the catalogue presented here have been obtained by cross-referencing the Tycho-2 to general spectral catalogue. The ACT and the Hipparcos catalogues have been additionally used for this purpose. Double, multiple, and variable stars, as well as erroneous proper motions were excluded from the final version. As a result, it contains equatorial coordinates and proper motions in the ICRS/J2000.0 system, B_T and V_T Tycho magnitudes, the MK spectral classifications, the Tycho-2 identifier, and some other information for 169 843 stars down to $V_T = 11.5$ mag. Objects in the catalogue appear in order of right ascension increasing. The catalogue presents spectral type data only as a temperature class, a subclass, and a luminosity class and puts that into identical format for every star. Such a reformatting is necessary to use spectral classifications in statistical studies. Table 1 gives number of stars distributed for spectral types and luminosity classes. Among 79 stars not included in the table there are 40 subdwarfs and 39 carbon stars.

Table 1. Distribution of stars for spectral types and luminosity classes

Spectral type	V	IV	III	II	I	All stars
O	374	39	106	31	116	667
B	12788	3203	4908	1862	1430	24190
A	21210	5859	4053	1008	1010	33140
F	29891	2975	1578	416	423	35283
G	13915	5264	11083	501	276	31039
K	2582	1741	33472	788	267	38850
M	257	10	5887	259	172	6595
All stars	81017	19091	61087	4875	3694	169764

In the average the compiled catalogue is roughly ninety percent complete at $V_T = 10.5$ mag. Mean value of V_T is 8.7 and that of B_T is 9.5 mag. The catalogue is available to public access on the following URL: [`http://www.mao.kiev.ua/dept/cat3.html`].

APPLICATION OF COMPILED CATALOGUE

Starting with pioneering works by Schwarzschild, Lindblad, and Oort, the study of local stellar kinematics is known to provide important information about the structure and evolution of the Milky Way. Recent advances in such a study have been mainly achieved due to Hipparcos database, which combines considerable amount of highly accurate proper motions and parallaxes with astrophysical data. In the present paper we have reanalysed systematic and random motion of dwarf and giant populations taken from the catalogue compiled by us. Here we briefly review some key results of the analysis.

The systematic velocity field of about 70 000 B−M type dwarfs and 40 000 G5−K5 type giants within one kiloparsec of the Sun was investigated from the Ogorodnikov–Milne model of galactic rotation. This is three-dimensional model, which has the great advantage of being independent of any a priori dynamical model of the Galaxy. Most recently, Mignard [3] has used the same model to study of about 20 000 stars from the Hipparcos catalogue. However, here we significantly extend the sample under investigation. For this reason we are able to divide our sample into various spectral bins of typically 10 000 stars thus reaching more reliable statistics. Moreover, spectroscopic parallaxes derived in this work have led to considerably larger distances compared with those based on reliable Hipparcos parallaxes. Each spectral group may also be considered as statistically unbiased sample, because we applied several criteria for selection of objects to avoid risking to invalidate the conclusions. These criteria concern velocity, brightness and other properties of stars. Using three-dimensional kinematic model we have determined its eight parameters and three components of the solar motion with respect to various spectral groups. From the results it follows that the Oort–Lindblad model with B, A, f, and K parameters is sufficient to describe the global galactic rotation of both dwarfs and giants, belonging to disc population in the solar vicinity. Here B and A are the generalized Oort constants, f is the phase offset, K is the local expansion or contraction. As expected for the first two parameters, they have been estimated with high level of significance for all spectral groups. However, statistically significant values of f, K parameters have been only detected for B−A dwarfs and G5−K0 giants. It is especially noteworthy that there is a very close agreement between corresponding estimates of these parameters derived for young and old stars. Thus, besides an overall galactic rotation both groups show a remarkably similar irregularities of the systematic velocity field, characterized by the above parameters. These irregularities can be interpreted as contracting motion at mean rate $K = (-7.8 \pm 1.3)$ km s^{-1} kpc^{-1} and rotation around center, which lags by mean angle $f = 8.9^\circ \pm 1.7^\circ$ from the adopted galactic center. The results are slightly sensitive to various distance estimates based on spectroscopic or Hipparcos parallaxes. This gives some evidence that revealed anomalies of kinematics may be real. The value of phase offset f determined here is well consistent with the value $6.2^\circ \pm 1.5^\circ$ obtained by Mignard [3] from three-dimensional analysis of Hipparcos data. However, he has not derived significant values for K. The most probable cause of the discrepancy is using of different samples of stars due to different stellar content of the Hipparcos and the Tycho-2 catalogues. Nevertheless, in roughly accordance with ours negative non-zero values of K parameter can be found in paper [5] for young stars situated outside the Gould Belt region. On the other hand, the group of K1$-$K5 giants exhibits only the familiar plane-parallel galactic rotation described by the Oort's constants A and B.

Using the estimates of Oort's constants we calculated their relevant combination $V = R(A - B)$, which yields rotational speed of the Galaxy at solar distance $R = 8.5$ kpc [1] from its center. According to such a relation the rotation velocity $V = (202 \pm 8)$ km s^{-1} for G5$-$K0 giants is the value slightly smaller than the value $V = (242 \pm 7)$ km s^{-1} for early type dwarfs, but it is compatible with the $V = (190 \pm 9)$ km s^{-1} for later K1$-$K5 giants. The relatively slow galactic rotation of K$-$M giants $V = (174 \pm 6)$ km s^{-1} derived by Miyamoto and Soma [4] from the ACRS Part 1 agrees quite well with our result for all giants considered. It should also be noticed that the present determination of circular velocity of early type dwarfs is consistent within the standard errors with recent value $V = (231 \pm 9)$ km s^{-1} estimated by Feast and Whitelock [1] from Hipparcos proper motions and parallaxes of cepheids.

The distribution of peculiar velocities is also examined to determine the orientation and the shape of the velocity ellipsoid as a function of stellar spectra. It has long been known that peculiar velocities of disc stars vary with spectral types. However, due to the lack of accurate kinematic data, a detailed study of such a relation has not been possible. The availability of Hipparcos parallaxes and proper motions allows to redetermine the velocity distribution functions in the solar vicinity and represents a major advance over earlier work. A number of studies have been devoted to derive the velocity ellipsoid parameters on this new base. In the present paper we summarize our results obtained from analysis of significantly larger sample of stars. For all spectral types we have obtained the classical order of principal axes of the velocity ellipsoid. It was also found that the vertex deviation (galactic longitude of direction of the largest principal axis) declines and the shape of the velocity ellipsoid gets rounder from early to late type stars. These conclusions are in a good agreement with those established in recent works, for example [2]. The values of derived vertex deviations, commonly used to parameterize the deviation from dynamical symmetry, are almost the same for both late type dwarfs and giants, thus yielding mean value of the vertex deviation $l_v = 11.1^\circ \pm 1.2^\circ$. According to Gomez *et al.* [2] this indicates that the mean age of both groups is also approximately equal and implies that there is dynamically significant evolution of the Galaxy disc at this age.

CONCLUSIONS

From compiled astrometric and astrophysic data we have redetermined as a function of spectral types the kinematics of main sequence stars and cool giants in the solar neighbourhood within about 1 kpc. On account of the unusually small accidental and systematic errors of the Tycho-2 proper motions we are able to detect significant deviations of stellar systematic motion from Oort's galactic rotation for early type dwarfs and G5$-$K0 giants. We have also performed the study of peculiar velocities of all stars considered. The resulting mean vertex deviation is $21.9^\circ \pm 1.4^\circ$ and $11.1^\circ \pm 1.2^\circ$ for young and old disc stars, respectively. In general, the presented estimates are close enough to those quoted in recent papers. As noticed by Gomez *et al.* [2], the persistence of the vertex deviation to late type stars implies that the Galaxy potential is significantly non-axisymmetric at the solar radius. They also suggest that spiral arms are mainly responsible for the non-axisymmetry.

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[3] *Mignard F.* Local galactic kinematic from Hipparcos proper motions // Astron. and Astrophys.–2000.–**354**, N 2.–P. 522–536.

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