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Internal kinematics of open star clusters

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Summary. Proper motion data have been used to study the internal kinematics in eight open star clusters. The dependence of the intrinsic dispersion in proper motion on stellar mass and radial distance from the cluster centre have been studied. In most clusters no such dependence is observed. Velocity isotropy has been observed in all the clusters studied here, except in NGC 2516, in which the radial and tangential components of the intrinsic velocity dispersion are different in the outer regions ($R > 2$ pc) of the cluster.

1 Introduction

Proper motion data for open star clusters provide velocity information in two orthogonal directions and also have the advantage of being available for a relatively large number of stars, located at varying distances from the cluster centre, and having different masses. Therefore, an observational study of internal motions and dynamics of open star clusters is possible by deriving intrinsic dispersions in the proper motion components of member stars. Recently such studies have been made for a number of open clusters, e.g. Pleiades (Jones 1970), Praesepe (Jones 1971), Orion (McNamara 1976), M 11 (McNamara & Sanders 1977), M 67 (McNamara & Sanders 1978), NGC 6494 (McNamara & Sanders 1983), and M 35 (McNamara & Sekiguchi 1986). Accurate determination of proper motion components with estimates of the associated errors are required for the evaluation of intrinsic dispersion in them. This is because both the intrinsic dispersion and the dispersion due to errors contribute to the observed dispersion in proper motion components (*cf.* McNamara & Sekiguchi 1986). Recently such data have become available for some open clusters, and the present work makes use of them.

2 Data and cluster membership

Internal motions based on proper motion data have been studied here for eight open clusters, namely NGC 2287, 2516, IC 2391, NGC 2669, 3532, 4103, 4755 and 5662. General information about these clusters and the source of proper motion data are given in Table 1. The proper motion studies in these cluster regions have probably been able to segregate member stars from field stars because the membership probability (P) histogram of all stars investigated for the proper motion data in each cluster region indicates that most of the investi-

Table 1. General information and the source of proper motion data.

Cluster	IAU Designation	log (age)	Number of samples	Proper motion data	
				Mean error (arcsec century^{-1})	source
NGC 2287	C0644-206	8.0	65	0.10	Ianna *et al.* (1987)
NGC 2516	C0757-607	8.0	96	0.07	King (1978b)
IC 2391	C0838-528	7.6	40	0.09	King (1979b)
NGC 2669	C0843-527	7.8	98	0.09	King (1979b)
NGC 3532	C1104-584	8.5	360	0.13	King (1978a)
NGC 4103	C1204-609	7.4	83	0.08	King (1979a)
NGC 4755	C1250-600	6.9	81	0.06	King (1980a)
NGC 5662	C1431-563	7.8	88	0.09	King (1980b)

gated stars belong to two well-separated groups; one with low *P*, i.e. $\leqslant 10$ per cent, and the other with high *P*, i.e. $\geqslant 70$ per cent, (e.g. see fig. 1, in Sagar 1987 for some open clusters). The probability of inclusion of field stars in the sample will be reduced if one considers stars with $P \geqslant 50$ per cent only, and the same has been done here for all the clusters except IC 2391. Membership probabilities are not given for this cluster and so members identified by King (1979b) have been included in the analysis. In the clusters under discussion, *UBV* photometric data are available for many members, and for some radial velocity data are available, in the catalogues of Mermilliod (1984a, b, 1986). Non-members on the basis of these data have also been excluded from the subsequent analysis. The sample stars have generally been measured on the same number of plate pairs. Measurements based on a few (<5) plate pairs have been excluded from the analysis. The mean error of the proper motion data and the number of sample stars '*n*' finally used in the study of internal motion of open star clusters are listed in Table 1.

3 The method

The procedure given by Jones (1970) is used to estimate the intrinsic dispersions in proper motion components. The observed proper motion dispersion in one coordinate can be written as

$$\sigma_0^2 = \frac{1}{n-1} \sum_{i=1}^{n} \mu_i^2, \tag{1}$$

where μ_i represents the proper motion of star *i* relative to the mean cluster motion and '*n*' is the sample size. As both the true dispersion and measurement errors contribute to σ_0, it has to be corrected for the errors to get the intrinsic dispersion. Assuming that the proper motion and error distributions are Gaussian, one has for the true dispersion σ_I as

$$\sigma_\text{I}^2 = \sigma_0^2 - \frac{1}{n} \sum_{i=1}^{n} \xi_i^2, \tag{2}$$

where ξ_i is the mean error of the proper motion of the *i*th star. The error in σ_I is

$$\varepsilon(\sigma_\text{I}) = \left\{ \frac{1}{4\sigma_\text{I}^2} [\varepsilon^2(\sigma_0^2) + \varepsilon^2(\sigma_\text{m}^2)] \right\}^{1/2}, \tag{3}$$

with

$$\varepsilon(\sigma_0^2)=\sigma_0^2\left(\frac{2}{n}\right)^{1/2}$$

and

$$\varepsilon(\sigma_{\rm m}^2)=\frac{\sqrt{2}}{n}\left(\sum_{i=1}^{n}\xi_i^4/n_i\right)^{1/2},$$

where n_i is the number of plate pairs on which star i appears.

4 Intrinsic proper motion dispersions

The intrinsic proper motion dispersions based on all sample stars are estimated using the method outlined in the last section and the results are listed in Table 2. It can be seen from Table 2 that the orthogonal components $\sigma_{\mu x}$ and $\sigma_{\mu y}$ of the intrinsic dispersion are generally equal within their associated errors. Therefore, weighted means σ_μ of the intrinsic dispersion in proper motion components have been used to study their dependence on stellar mass and radial distance from the cluster centre in the sections to follow. The cluster centre is defined as the point of maximum stellar surface density, in the way described by Sagar *et al.* (1988).

Table 2. Intrinsic dispersion in the proper motion components.

Cluster	$\sigma_{\mu x}$ (arcsec century^{-1})	$\sigma_{\mu y}$ (arcsec century^{-1})
NGC 2287	0.05 ± 0.02	0.06 ± 0.01
NGC 2516	0.08 ± 0.01	0.07 ± 0.01
IC 2391	0.40 ± 0.05	0.37 ± 0.04
NGC 2669	0.17 ± 0.02	0.18 ± 0.02
NGC 3532	0.06 ± 0.02	0.09 ± 0.01
NGC 4103	0.04 ± 0.01	0.06 ± 0.01
NGC 4755	0.08 ± 0.01	0.09 ± 0.01
NGC 5662	0.07 ± 0.02	0.11 ± 0.02

4.1 FUNCTION OF MASS

The dependence of intrinsic velocity dispersion on stellar mass is important for the study of stellar dynamics of star clusters. In order to investigate this, the entire sample has been divided into either four or two V-magnitude bins. The number of bins is guided by the need to have a statistically significant number of stars, generally more than 20, in each bin. The V-magnitude range of bin is converted into the mass range by assigning appropriate masses to their main sequence position (Schmidt-Kaler 1982). The apparent distance moduli used here are taken from Janes & Adler (1982). The intrinsic dispersion in proper motion σ_μ and number of sample stars N for each bin of a cluster are given in Table 3. It can be seen from this table that the σ_μ of different mass groups of a cluster are the same within their associated errors, except IC 2391 where the massive stars have lower values of σ_μ compared with the low-mass stars.

Table 3. Dependence of intrinsic dispersion in proper motion on stellar mass and radial distance from the cluster centre.

Cluster	Radius (arcmin)	Range in V (mag)	Mass range ($M/M_\odot$)	σ_μ (arcsec century^{-1})	N
NGC 2287		6.9–10.4	8.3–2.9	0.06 ± 0.01	33
		10.4–11.7	2.9–1.7	0.05 ± 0.02	32
	$r<10$			0.05 ± 0.01	30
	$10\leqslant r<23$			0.06 ± 0.01	35
NGC 2516		5.2–8.8	12.0–3.5	0.10 ± 0.02	20
		8.8–9.8	3.5–2.4	0.06 ± 0.02	29
		9.8–10.8	2.4–1.7	0.06 ± 0.01	27
		10.8–11.8	1.7–1.3	0.07 ± 0.02	20
	$r<7$			0.07 ± 0.02	21
	$7\leqslant r<13$			0.07 ± 0.01	27
	$13\leqslant r<19$			0.07 ± 0.02	24
	$19\leqslant r<38$			0.08 ± 0.02	24
IC 2391		9.0–11.0	1.5–1.0	0.27 ± 0.04	18
		11.0–12.6	1.0–0.8	0.45 ± 0.05	22
	$r<40$			0.36 ± 0.04	21
	$40\leqslant r<84$			0.38 ± 0.05	19
NGC 2669		6.7–10.0	6.3–4.3	0.18 ± 0.02	25
		10.0–11.3	4.3–3.4	0.16 ± 0.02	22
		11.3–11.7	3.4–2.8	0.18 ± 0.02	25
		11.7–12.7	2.8–2.0	0.16 ± 0.02	26
	$r<13$			0.13 ± 0.02	24
	$13\leqslant r<24$			0.17 ± 0.02	19
	$24\leqslant r<45$			0.15 ± 0.02	21
	$45\leqslant r<120$			0.21 ± 0.02	34
NGC 3532	$r<14$	7.4–10.0	5.6–3.6	0.08 ± 0.03	33
	$14\leqslant r<24$	7.4–10.0	5.6–3.6	0.08 ± 0.03	26
	$24\leqslant r<40$	7.4–10.0	5.6–3.6	0.11 ± 0.04	26
	$40\leqslant r<71$	7.4–10.0	5.6–3.6	–	
	$r<14$	10.0–10.9	3.6–1.7	0.08 ± 0.04	18
	$14\leqslant r<24$	10.0–10.9	3.6–1.7	0.05 ± 0.07	22
	$24\leqslant r<40$	10.0–10.9	3.6–1.7	0.09 ± 0.03	31
	$40\leqslant r<71$	10.0–10.9	3.6–1.7	–	
	$r<14$	10.9–11.8	1.7–1.3	0.12 ± 0.04	16
	$14\leqslant r<24$	10.9–11.8	1.7–1.3	0.12 ± 0.04	22
	$24\leqslant r<40$	10.9–11.8	1.7–1.3	0.10 ± 0.03	29
	$40\leqslant r<71$	10.9–11.8	1.7–1.3	0.09 ± 0.06	16
	$r<14$	11.8–13.0	1.3–1.0	0.08 ± 0.07	16
	$14\leqslant r<24$	11.8–13.0	1.3–1.0	0.09 ± 0.06	23
	$24\leqslant r<40$	11.8–13.0	1.3–1.0	0.16 ± 0.04	27
	$40\leqslant r<71$	11.8–13.0	1.3–1.0	0.09 ± 0.04	24
		7.4–10.0	5.6–3.6	0.07 ± 0.02	97
		10.0–10.9	3.6–1.7	0.09 ± 0.02	90
		10.9–11.8	1.7–1.3	0.09 ± 0.02	83
		11.8–13.0	1.3–1.0	0.08 ± 0.02	90
	$r<14$			0.08 ± 0.02	83
	$14\leqslant r<24$			0.09 ± 0.02	93
	$24\leqslant r<40$			0.12 ± 0.02	113
	$40\leqslant r<71$			0.09 ± 0.02	71

Table 3. – *continued*

Cluster	Radius (arcmin)	Range in V (mag)	Mass range ($M/M_\odot$)	σ_μ (arcsec century^{-1})	N
NGC 4103		8.8–11.0	11.0–5.0	0.04 ± 0.01	23
		11.0–12.0	5.0–3.6	0.06 ± 0.01	24
		12.0–12.3	3.6–3.4	0.06 ± 0.02	16
		12.3–12.7	3.4–2.8	0.05 ± 0.03	20
	$r < 4$			0.07 ± 0.02	24
	$4 \leqslant r < 9$			0.04 ± 0.02	18
	$9 \leqslant r < 18$			0.07 ± 0.02	18
	$18 \leqslant r < 30$			0.07 ± 0.02	23
			36.0–11.0		
NGC 4755		5.8–10.1	11.0–7.8	0.06 ± 0.02	23
		10.1–11.0	11–7.8	0.08 ± 0.02	20
		11.0–11.5	7.8–6.6	0.10 ± 0.02	21
		11.5–12.3	6.6–5.0	0.10 ± 0.02	17
	$r < 2.7$			0.08 ± 0.02	22
	$2.7 \leqslant r < 6$			0.08 ± 0.03	20
	$6 \leqslant r < 14$			0.10 ± 0.02	18
	$14 \leqslant r < 36$			0.10 ± 0.02	21
NGC 5662		7.0–10.2	11.0–3.6	0.08 ± 0.02	18
		10.2–11.2	3.6–2.5	0.09 ± 0.02	19
		11.2–12.0	2.5–2.0	0.07 ± 0.02	25
		12.0–12.6	2.0–1.6	0.11 ± 0.02	26
	$6 \leqslant r < 10$			0.07 ± 0.03	18
	$10 \leqslant r < 22$			0.09 ± 0.02	24
	$22 \leqslant r < 37$			0.11 ± 0.02	23
	$37 \leqslant r < 63$			0.15 ± 0.03	23

4.2 RADIAL DEPENDENCE

To study the radial dependence of σ_μ, we again divided the entire sample stars into either four or two radial bins and estimated σ_μ for each bin. The results and number of sample stars are again given in Table 3. In NGC 3532, the radial dependence of σ_μ has also been studied as a function of stellar mass. One can easily notice from Table 3 that there is no statistically significant radial dependence of σ_μ in all the clusters under discussion. The values of σ_μ for different radial bins of a cluster are the same within their associated errors, except in the case of NGC 2669 where the stars located inside $r < 45$ arcmin have lower values of σ_μ compared with the outer stars. Gieseking (1981) also found no statistically significant radial dependence of the intrinsic dispersions in radial velocity measurements of NGC 3532.

5 Velocity anisotropy

To gain some information about the anisotropy of the velocity distribution, each star's proper motion and error were computed along an axis pointing towards, and an axis perpendicular to, the cluster centre. The axis towards the cluster centre will be called the radial direction and that perpendicular to it the tangential direction. The intrinsic proper motion dispersions are then computed along these axes using all the sample stars and also as a function of radius, by dividing the sample stars into bins as in the last section. The results are given in Table 4, where the angular radial distances r and proper motion dispersions σ_μ have been converted into

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Table 4. Radial dependence of the radial and tangential velocity dispersions.

Cluster	Range in radius (pc)	σ_{vr} (Km s^{-1})	σ_{vt} (Km s^{-1})	N
NGC 2287	$R<0.6$	1.6 ± 0.6	0.9 ± 0.9	30
	$0.6\leqslant R<5.7$	0.9 ± 0.9	2.2 ± 0.6	35
	$0\leqslant R<5.7$	1.3 ± 0.6	1.9 ± 0.3	65
NGC 2516	$R<0.8$	1.7 ± 0.6	1.2 ± 0.6	21
	$0.8\leqslant R<1.5$	1.7 ± 0.4	0.6 ± 0.8	27
	$1.5\leqslant R<2.2$	1.9 ± 0.4	1.0 ± 0.6	24
	$2.2\leqslant R<4.4$	2.1 ± 0.4	1.0 ± 0.4	24
	$0\leqslant R<4.4$	1.7 ± 0.2	1.0 ± 0.2	96
IC 2391	$R<1.9$	2.6 ± 0.5	3.3 ± 0.5	21
	$1.9\leqslant R<3.9$	3.3 ± 0.5	2.9 ± 0.5	19
	$0\leqslant R<3.9$	2.9 ± 0.3	3.0 ± 0.4	40
NGC 2669	$R<3.9$	7.1 ± 1.5	5.5 ± 1.0	24
	$3.9\leqslant R<7.3$	9.1 ± 2.0	8.1 ± 1.5	19
	$7.3\leqslant R<13.6$	5.0 ± 1.5	9.6 ± 2.0	21
	$13.6\leqslant R<36.3$	11.6 ± 1.5	10.1 ± 1.5	34
	$0\leqslant R<36.3$	9.1 ± 1.0	8.6 ± 1.0	98
NGC 3532	$R<1.8$	1.1 ± 0.9	2.0 ± 0.4	83
	$1.8\leqslant R<3.1$	1.7 ± 0.7	0.9 ± 1.1	93
	$3.1\leqslant R<5.2$	0.9 ± 0.9	2.4 ± 0.4	113
	$5.2\leqslant R<9.3$	1.1 ± 0.9	2.4 ± 0.7	71
	$0\leqslant R<9.3$	1.3 ± 0.4	2.0 ± 0.2	360
NGC 4103	$R<1.6$	—	4.6 ± 1.3	24
	$1.6\leqslant R<3.6$	2.6 ± 2.0	3.3 ± 2.0	18
	$3.6\leqslant R<7.1$	4.0 ± 1.3	1.3 ± 3.3	18
	$7.1\leqslant R<11.9$	3.3 ± 1.3	5.9 ± 1.3	23
	$0\leqslant R<11.9$	2.6 ± 1.3	4.0 ± 0.7	83
NGC 4755	$R<1.6$	6.8 ± 2.9	6.8 ± 2.9	22
	$1.6\leqslant R<3.5$	7.8 ± 2.9	1.0 ± 10.7	20
	$3.5\leqslant R<8.1$	8.7 ± 2.9	11.6 ± 2.9	18
	$8.1\leqslant R<20.9$	7.8 ± 2.9	11.6 ± 2.9	21
	$0\leqslant R<20.9$	7.8 ± 1.0	8.7 ± 1.0	81
NGC 5662	$R<1.7$	0.9 ± 1.5	1.5 ± 0.9	18
	$1.7\leqslant R<3.8$	2.0 ± 0.9	3.2 ± 0.9	24
	$3.8\leqslant R<6.5$	3.2 ± 0.9	3.2 ± 0.9	23
	$6.5\leqslant R<11.0$	2.3 ± 1.2	3.5 ± 0.9	23
	$0\leqslant R<11.0$	2.3 ± 0.6	2.9 ± 0.3	88

radial distances R and velocity dispersions σ_v, using the relations

$$R(\text{pc})=0.29\,D(\text{Kpc})\,r\,(\text{arcmin})\text{ and}$$
$$\sigma_v\,(\text{Km s}^{-1})=48.5\,D(\text{Kpc})\,\sigma_\mu\,(\text{arcsec century}^{-1}),\qquad(4)$$

where D is the distance to the cluster; taken from Janes & Adler (1982).

A comparison of the intrinsic velocity dispersion, based on all sample stars in radial direction σ_{vr} with that in tangential direction σ_{vt} is shown in Fig. 1. This diagram indicates that $\sigma_{vr}\approx\sigma_{vt}$ in the clusters studied here, if one considers their associated errors except in NGC 2516. For this cluster $\sigma_{vr}>\sigma_{vt}$ is observed.

The following points can be noticed from Table 4 about the radial dependence of σ_{vr}, σ_{vt} and velocity anisotropy:

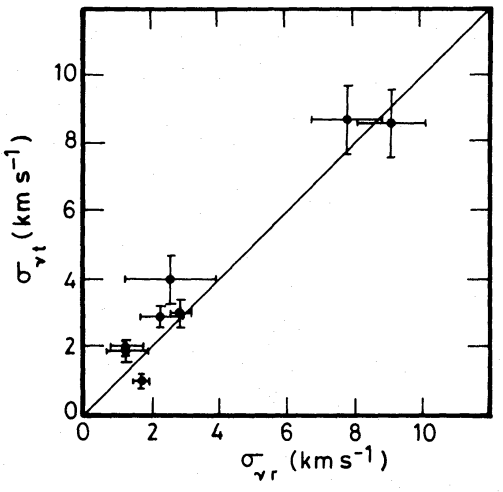

Figure 1. Plot of σ_{vt} versus σ_{vr}. They are based on all sample stars. Straight line represents $\sigma_{vt}=\sigma_{vr}$.

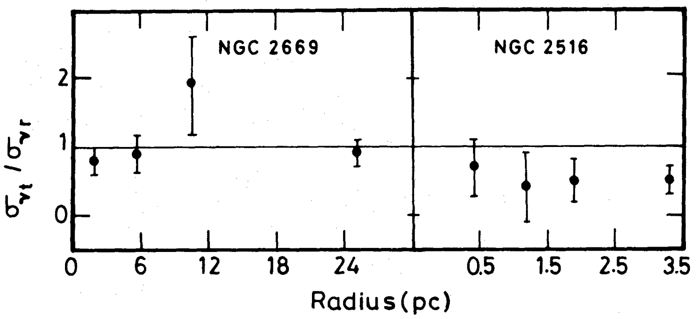

Figure 2. Radial dependence of ratio σ_{vt}/σ_{vr}. Straight line represents $\sigma_{vt}=\sigma_{vr}$. NGC 2516 shows velocity anisotropy in the outer regions, while NGC 2669 is representative of clusters showing velocity isotropy.

(i) In the various radial bins for NGC 2287, IC 2391, NGC 2669, 3532, 4103, 4755 and 5662, σ_{vr} and σ_{vt} are the same within their associated errors, indicating the absence of any significant velocity anisotropy.

(ii) Stars located at $R>2$ pc have $\sigma_{vr}>\sigma_{vt}$ and appear to be the cause of velocity anisotropy in NGC 2516.

To illustrate the above points more clearly, the ratios σ_{vt}/σ_{vr} for NGC 2516 and 2669 are plotted against radius in Fig. 2. There is no radial dependence of σ_{vt}/σ_{vr} in NGC 2669. This is a representative case of the presence of velocity isotropy ($\sigma_{vt}/\sigma_{vr}\approx 1$) at all radial distances in the star clusters studied here, except in NGC 2516 where the velocity anisotropy ($\sigma_{vt}/\sigma_{vr}\approx 0.5$, significantly different from 1) is evidently present in the outer region ($R>2$ pc) of the cluster.

6 Discussion

We now discuss the results obtained above, regarding the different aspects of internal kinematics of the open clusters.

6.1 EQUIPARTITION OF ENERGY

The study of the dependence of σ_{μ} on stellar mass and radius reported in Sections 4.1 and 4.2 indicates that there is no radial and mass dependence of σ_{μ} in all the clusters except IC 2391, where only mass dependence of σ_μ is observed. A similar relation was found for Praesepe by Jones (1971). Such relations are absent in the other clusters studied here, however, and also in some other well-studied open clusters (see McNamara & Sekiguchi 1986). Whether the observed mass dependence of σ_μ is due to mass segregation caused dynamically or not is unclear. Recent studies indicate that initial star formation processes can also lead to a similar distribution (Mathieu 1983; Terlevich 1987; Sagar *et al.* 1988).

Theoretical predictions concerning the relationship between stellar mass and velocity are subject to a number of uncertainties. The effects of encounters with molecular clouds, dynamical evolution, galactic tidal forces and vestiges of star clusters' initial formation conditions, could well be present in the velocity distributions within star clusters. The simple energy equipartition relation that the velocity dispersions of two mass groups are inversely related to the square root of their average mass ratio may not be valid for all the clusters under these circumstances. The effect of galactic tidal field is to yield a flattened global velocity–mass relation. Clusters studied here generally have ages $\sim 10^8$ yr (see Table 1). Hence, they may be dynamically relaxed. It is therefore interesting to note that the $1/\sqrt{m}$ dependence of σ_μ, expected from equipartition of energy, is not found in the clusters studied here.

6.2 VELOCITY ANISOTROPY

Velocity anisotropy has been observed only in NGC 2516, based on the dispersion in velocity along the tangential and radial directions. The velocity anisotropy is absent close to the cluster centre but present in the outer parts of the cluster. The inclusion of relatively more non-members in the outer region of the cluster may cause greater velocity anisotropy there, but the statistically expected number of field stars in our entire sample based on its median membership probability is only two. Consequently, the possibility that non-members could be responsible for the observed velocity anisotropy in the outer part of the cluster is completely ruled out. This observed fact is in agreement with the theoretical expectations (*cf.* Prata 1971). In the interior of a cluster, relaxation times are short enough to establish velocity isotropy.

6.3 INTRINSIC DISPERSION IN VELOCITY

The weighted mean intrinsic dispersion of the proper motion components given in Table 2, σ_μ in arcsec century^{-1}, has been converted into one-dimensional intrinsic velocity dispersion, σ_v in km s^{-1}, using equation (4). The resulting values are 1.6, 1.6, 2.9, 8.2, 1.7, 3.3, 8.2 and 2.6 km s^{-1} for the open star clusters NGC 2287, 2516, IC 2391, NGC 2669, 3532, 4103, 4755 and 5662, respectively. The present estimate for NGC 3532 agrees very well with the value of $\sigma_v = 1.5 \pm 0.3$ km s^{-1} given by Gieseking (1981) on the basis of relative radial velocity observations. The values of σ_v are generally $\leqslant 3$ km s^{-1}, with a typical value of ~ 2 km s^{-1}, except in NGC 2669 and 4775 where they are very large. The typical value for the one-dimensional intrinsic dispersion in velocity is in fair agreement with the values obtained recently using the precise (error $\leqslant 1$ km s^{-1}) radial velocity measurements for some open clusters (see Mathieu 1986, Sagar & Bhatt 1988). The large values obtained in the case of NGC 2669 and 4755 could be because of either including a large number of field stars in their determinations, or using overestimated distances.

To get an idea of the effect of inclusion of field stars in NGC 2669 and 4755, we estimated the statistically expected number of field stars in our sample on the basis of its median membership probability, and find that at most about 14 per cent of sample stars in NGC 2669 and 10 per cent in NGC 4755 could be field stars. It seems unlikely that such a small percentage of field star contamination could produce such large intrinsic velocity dispersions.

The distances used here are photometric and they have errors generally of the order of 10–30 per cent but in some cases errors may be very large. For example, in the case of NGC 4755, distances vary from 800–2400 pc (see Perry, Franklin & Landolt 1976). The latest distance estimate for this cluster is 1.9 Kpc (Shobbrook 1984). However, if one assumes the distance to the cluster to be 800 pc, then the value of σ_v becomes ~ 3 km s^{-1}. The only distance estimate available for NGC 2665 is based on photographic data by Vogt & Moffat (1973) and its probable error is not known.

Thus while it is possible that the distances to NGC 2669 and 4755 used here are overestimates and the cluster one-dimensional internal velocity dispersions are typical of other clusters ($\leqslant 3$ km s^{-1}) we also note here that the large velocity dispersions derived for these clusters could be real, as in the α Per cluster (Fresneau 1986). However, the reality of the presently estimated large velocity dispersion can be checked when more accurate radial velocity measurements become available for the cluster member stars.

7 Conclusions

Internal kinematics based on proper motion data have been studied in eight open clusters. They are not of very high precision, but are adequate to estimate internal motions and study their dependence on stellar mass and radial distance from the cluster centre. Except in IC 2391, intrinsic dispersions are found to be independent of stellar mass and radial distance in all the clusters studied here. Massive stars of IC 2391 have lower values of σ_μ, relative to the low-mass stars. The finding of independence of σ_μ on mass indicates that the combined effect of the various processes (see Section 6.1) acting on a cluster tends to produce mass independence of σ_μ. We have observed velocity isotropy in all the clusters, except in NGC 2516. In this cluster stars located in the outer region ($R > 2$ pc) show statistically significant effects of velocity anisotropy.

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