HIPPARCOS

Star Distribution Models (2)

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Summary

An analytical expression is given for the smoothed star density as function of blue magnitude and galactic coordinates (b, ℓ).

The formula

A previous note, "Star Distribution Models" (1982-11-14) gave the star density as function of blue magnitude (B) and galactic latitude (b). The present note extends the formula with a term depending on galactic longitude (ℓ).

Let N(B, b, ℓ) be the (smoothed) number of stars per square degree at galactic coordinates (b, ℓ) brighter than B. For all B < 16 and all positions we have approximately

$$\lg[N(B,b,\ell)] = \lg[N(B,b)] - e^{0.39(B-22)}\cos^2 b - $$

$$- 0.1\left[1 + \ln\left(1 + e^{0.65(B-12.7)}\right)\right] \lg\left[1 - \frac{1.56 - 0.60\cos b}{1 + e^{-0.78(B-9)}}\cos b \cos \ell\right] \qquad (1)$$

in which

$$\lg[N(B,b)] = -3.65 + 0.489\,B - 0.002\,B^2 -$$

$$- (0.86 - 0.084\,B + 0.007\,B^2)(1.4|\sin b| - 0.4\sin^2 b) \qquad (2)$$

gives the density averaged with respect to ℓ:

$$N(B,b) = (2\pi)^{-1}\int_{-\pi}^{\pi} N(B,b,\ell)\,d\ell \qquad (3)$$

Averaging also with respect to b (i.e. over the full sky), we have

$$N(B) = 2^{-1}\int_{-\frac{1}{2}\pi}^{\frac{1}{2}\pi} N(B,b)\cos b\,db \qquad (4)$$

which for B < 16 is approximated by

$$\lg N(B) = -4.08 + 0.528\,B - 0.005\,B^2 \qquad (5)$$

The densities given by (2) and (5) are about 0.02 dex smaller than in the previous note, and the coefficient for B in (5) is also slightly changed to give better consistency with (2).

The general form of dependence on B and b was adopted from Allen (1973), but with a zero point shift in lg(N) such that the total number of stars to B = 8.5 agrees with counts in the CSI (Turon Lacarrieu, 1980). The variations with longitude were taken from the Galaxy model by Bahcall and Soneira (1980).

Tables 1 to 3 give some comparisons with these sources.

Table 1. Comparison of (2) with Allen (1973). The table gives $\lg(N_{LL}/N_{Allen})$.

B	b = 0°	5°	10°	20°	30°	40°	50°	60°	90°	all sky
0		(.25)			(.13)			(-.03)		(.17)
2		(.06)			(.09)			(-.04)		(.14)
4	.02	.03	.01	.01	.05	.06	.04	.01	.04	.06
6	.03	.04	.04	.05	.07	.06	.04	.03	.02	.05
8	.08	-.01	.08	.08	.07	.07	.05	.03	.04	.07
10	.07	.07	.07	.07	.07	.05	.04	.03	.05	.08
12	.05	.06	.08	.06	.04	.04	.02	.03	.04	.08
14	.08	.07	.08	.07	.05	.05	.04	.05	.04	.07
16	.18	.10	.12	.10	.11	.09	.09	.09	.11	.11

Table 2. Comparison of (1) with Bahcall and Soneira (1980): $\lg(N_{LL}/N_{BS})$.

B	b = 20° ℓ = 0°	20° 90°	20° 180°	30° 0°	30° 90°	30° 180°	50° 0°	50° 90°	50° 180°	90° -
10	.20	.21	.22	.24	.25	.25	.16	.16	.16	.17
12	.29	.31	.31	.31	.31	.31	.20	.19	.19	.19
14	.33	.36	.36	.32	.32	.32	.18	.18	.18	.16
16	.34	.37	.38	.31	.33	.33	.18	.19	.19	.17

Table 3. Comparison of (2) and (5) with the CSI (Turon, 1980): $\lg(N_{LL}/N_{CSI})$.

B	b = 0 - 5°	5 - 10°	10 - 20°	20 - 40°	40 - 60°	60 - 90°	all sky
8.0							.013
8.5							.001
8.8	-.038	-.022	.004	.019	-.007	-.023	.001
9.0							.004
9.5							.011

Galactic coordinates

For convenience I give here the complete and accurate transformation between ecliptical coordinates (λ, β), referred to the standard epoch J2000.0, and galactic coordinates (b, ℓ):

$$\begin{pmatrix} \cos b \cos \ell \\ \cos b \sin \ell \\ \sin b \end{pmatrix} = \begin{pmatrix} -.0548777621 & -.9938212536 & -.0964766664 \\ .4941083214 & -.1109918634 & .8622863637 \\ -.8676666398 & -.0003495777 & .4971463365 \end{pmatrix} \begin{pmatrix} \cos \beta \cos \lambda \\ \cos \beta \sin \lambda \\ \sin \beta \end{pmatrix} \quad (6)$$

References

Allen, C.W.: 1973, Astrophysical Quantities, 3rd ed., The Athlone Press, London (p. 243)

Bahcall, J.N. and Soneira, R.M.: 1980, Astrophys. J. Suppl. 44, 73 (Table 6)

Turon Lacarrieu, C.: 1980, Preliminary remarks on the definition of a survey, Hipparcos working paper 1980 Oct 8 (Table 1 and 2)