GALACTIC DUST DISTRIBUTION IN THE SOLAR NEIGHBORHOOD

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Abstract. Using the Shklovsky-Minkowski-Aller constant mass method of distances to planetary nebulae, a model of the Galactic dust distribution in the vicinity of the Sun has been determined. Distances are determined in part from extinctions derived from radio continuum to Hβ flux ratios for an assumed electron temperature of 7000 K. The distance scale is based on the brightness of planetary nebulae in the Magellanic Clouds (Seaton, 1968).

In an extension of the work of Cahn and Kaler (1971) an empirically determined dust distribution in the vicinity of the Sun has been developed. The overall features of the dust distribution are based upon optical color excess measurements and 21 cm hydrogen position determinations. A recently revised set of Hβ extinctions was then used to refine the positions of the dust.

In the Cahn and Kaler paper, hereinafter referred to as CK, a Mills (1959) spiral was picked whose parameters gave the best agreement with the then known Hβ extinctions. It was realized at that time that such an idealization of the local spiral arms was too inflexible to permit accurate predictions of extinctions over the accessible regions of the Galaxy. It was then decided to try to develop an empirical dust map, which would provide the desired flexibility. The first step in constructing the map was to initialize the model with existing measurements. We used the color excess map developed by Fitzegerald (1968) as shown in Figure 1 and the 21 cm maps of Winnberg (1968) shown in Figure 2 and that of Kerr and Weaver as given by Simonson (1970) in Figure 3. In order to refine these positions we then extended and refined the extinctions in CK as given in Table I. These values are based upon an electron temperature of 7000 K rather than 5000 K as suggested both by Kaler and by Peimbert (1971). The radio fluxes include unpublished measurements by Cahn, Rubin and Hermann, and Aller and Milne in addition to those already reported in CK.

The resulting adjusted map is shown in Figure 4. In order to store such a large fraction of the Galaxy on the computer, only two levels of extinction, 0.407 kpc^{-1} and 2.033 kpc^{-1} were used, the latter being the shaded area in Figure 4. To account for the finite thickness of the dust distribution, the values of extinction in the plane were reduced by the Gaussian factor $\exp[-(z/150\text{ pc})^2]$ where z is height above or below the plane. In homogeneous media of either the low or high specific extinction, the integrals to infinity along the line of sight give extinctions of $0.061\csc b_{\rm II}$ and $0.305\csc b_{\rm II}$ respectively, where $b_{\rm II}$ is the galactic latitude. Figure 4 represents a fit to the measured extinctions resulting in a correlation coefficient of 0.99.

It is to be understood that with such a limited list of calibrators, each of whose distance is only statistically accurate, that the map is still very speculative. In Figure 4,

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TABLE I

Galactic coordinates

Nebula	l_{II}	b_{II}	Distance (pc)	Radius (pc)	Extinction
IC 4634	0.38	12.22	3680	0.075	0.61
NGC 6369	2.44	5.85	1040	0.070	2.21
NGC 6620	5.88	−6.15	6360	0.077	1.49
NGC 6445	8.07	3.90	1360	0.109	1.27
NGC 6309	9.66	14.81	2800	0.094	0.93
IC 4593	25.41	40.73	2990	0.093	0.14
NGC 6818	25.86	−17.90	1970	0.087	0.20
NGC 6751	29.23	−5.93	2570	0.131	0.52
NGC 6778	34.61	−6.71	2850	0.109	0.68
NGC 6572	34.62	11.84	1670	0.058	0.44
NGC 7293	36.24	−57.10	150	0.293	0.05
NGC 7009	37.76	−34.58	1270	0.087	0.20
CN3-1	38.26	12.09	4910	0.064	0.59
NGC 6781	41.84	−2.98	670	0.173	1.27
NGC 6210	43.12	37.76	2060	0.081	0.15
NGC 6804	45.75	−4.59	1640	0.095	1.00
NGC 6879	57.23	−8.93	6750	0.082	0.65
NGC 6886	60.14	−7.74	3980	0.073	1.15
NGC 6853	60.83	−3.69	260	0.211	0.10
NGC 6720	63.15	13.98	840	0.141	0.21
NGC 6842	65.91	0.60	1560	0.180	1.01
NGC 6894	69.48	−2.62	1510	0.162	0.92
NGC 7027	84.92	−3.49	1210	0.041	1.54
HU1-2	86.54	−8.83	5350	0.065	0.75
NGC 7354	107.84	2.31	1640	0.080	1.86
NGC 40	120.02	9.87	1180	0.104	0.90
IC 3568	123.66	34.55	2520	0.110	0.34
IC 289	138.82	2.81	1430	0.128	1.49
NGC 1501	144.56	6.55	1150	0.144	1.11
NGC 1514	165.53	−15.29	720	0.120	0.63
NGC 23712	189.16	19.83	1670	0.176	0.22
J 320	190.39	−17.77	5050	0.079	0.72
NGC 2022	196.68	−10.93	2640	0.124	0.47
NGC 2392	197.88	17.40	1190	0.129	0.35
NGC 1535	206.48	−40.57	2230	0.099	0.12
IC 418	215.22	−24.27	1740	0.053	0.33
IC 2165	221.33	−12.40	3520	0.068	0.85
NGC 2440	234.84	2.43	1360	0.109	0.63
NGC 2610	239.64	13.95	1810	0.151	0.77
NGC 3242	261.06	32.06	1040	0.094	0.30
NGC 2818	261.98	8.60	1750	0.170	0.67
NGC 3132	272.11	12.39	1220	0.133	0.28
NGC 4361	294.11	43.62	940	0.186	0.17
NGC 5307	312.38	10.56	2980	0.091	0.76
IC 4406	319.69	15.74	2140	0.104	0.47
NGC 5882	327.84	10.09	2230	0.076	0.44
NGC 6326	338.20	−8.38	2930	0.086	0.81
NGC 6153	341.84	5.46	1390	0.083	1.26
NGC 6072	342.16	10.83	990	0.168	1.15
NGC 6563	358.50	−7.33	1400	0.146	0.62

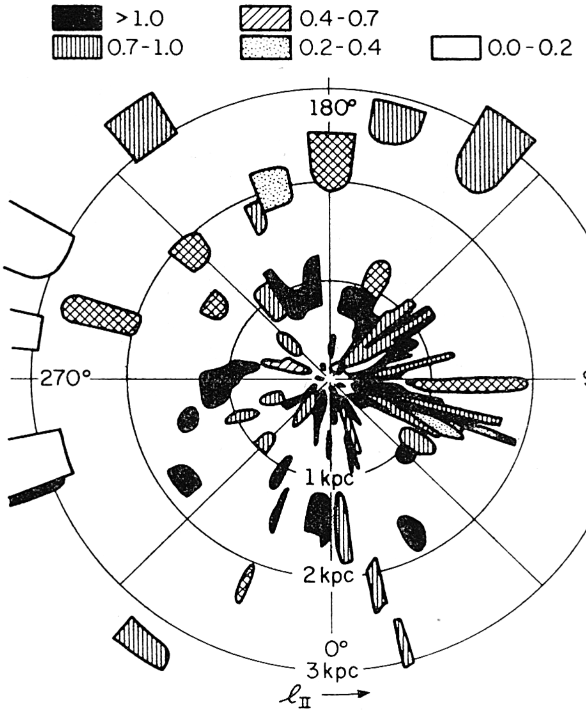

Fig. 1. Color excesses of Fitzgerald (1968). Darkened areas indicate excesses greater than 1 mag. kpc^{-1}.

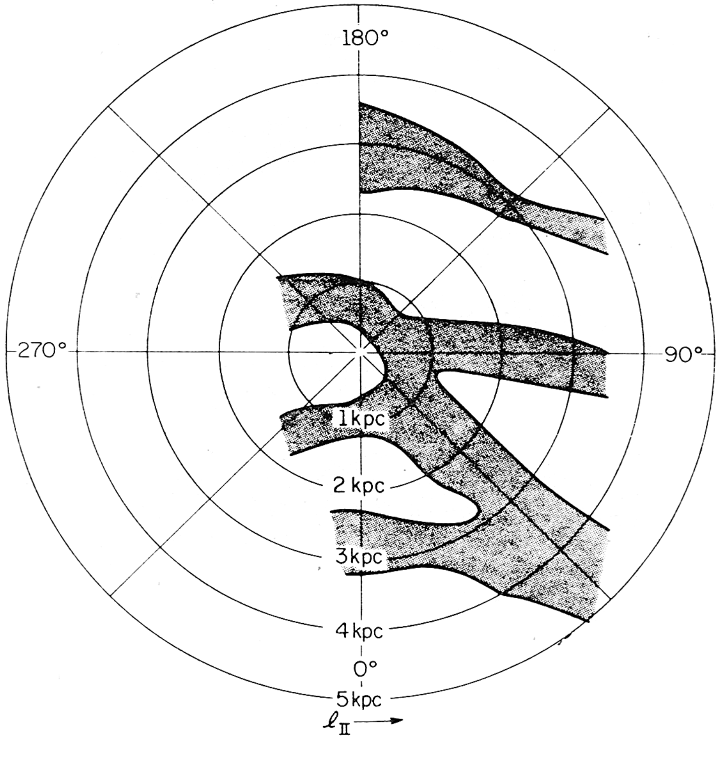

Fig. 2. Part of 21 cm map of Winnberg (1968)

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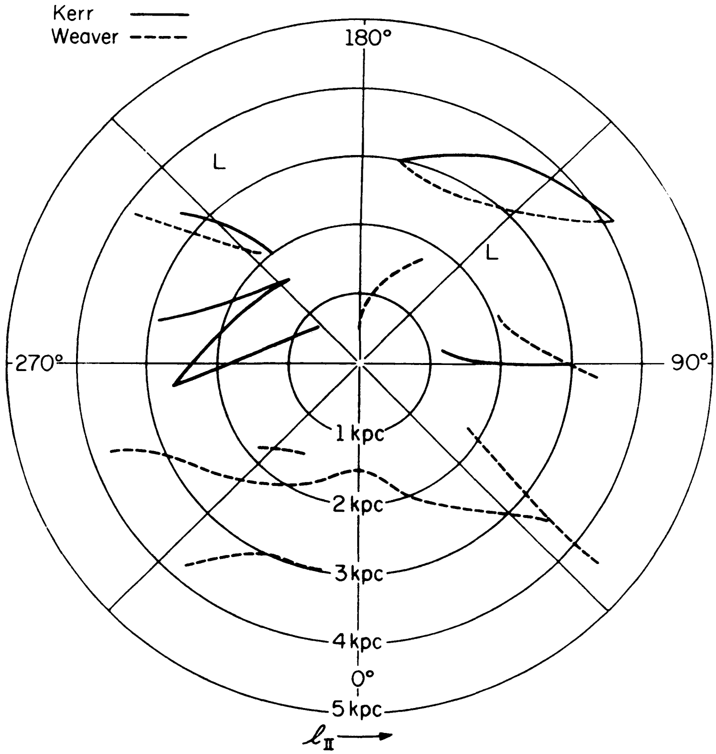

Fig. 3. Part of 21 cm map of Kerr and Weaver data as given in Simonson (1970).

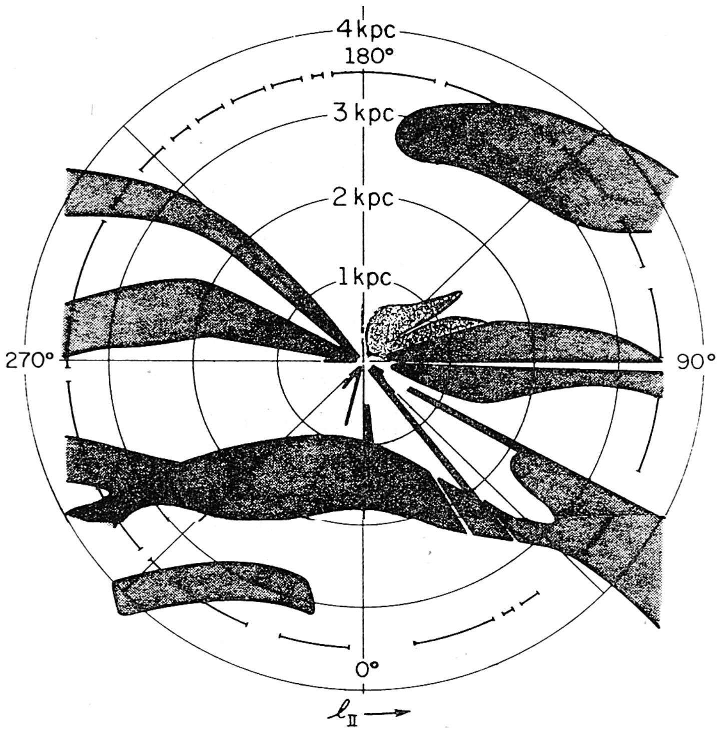

Fig. 4. Adjusted map of dust distribution in accord with planetary nebular extinctions and distances. Broken line indicates coverage (c.f. text).

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the intermittent line at 3.5 kpc represents the incompleteness of the data. The solid part of the line represents uncalibrated regions of the map. In addition, regions closest to the Sun are most reliable, since the average value of b_{II} is 15°.

Finally, it is to be hoped that the present work can be coordinated with determinations of color excess to help determine R, the ratio of total to selective absorption.

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