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A STUDY ON THE INITIAL MASS FUNCTION OF HALO STARS

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ABSTRACT

The sample of subdwarfs are selected from LHS catalogue on the bases of the reduced proper motion diagram utilizing Chui criteria, and confirmed with the available photometric and/or kinematic data. Among them, 20 subdwarfs have trigonometric parallaxes with accuracy better than 20 %. The color-absolute magnitude relation is derived with them. By adopting this color-magnitude relation and V/V_m method, we have derived the subdwarf luminosity function over the absolute magnitude range of M_v = 4.5 and 9.5. This halo luminosity function is consistent with that of Eggen(1987). By adopting the available mass-luminosity relations for halo stars, we have found that the halo IMF is steeper than disk IMFs of Scalo(1986) and Salpter(1955) in this small mass region.

Key Words : initial mass function, subdwarf, halo stars, halo luminosity function.

I. INTRODUCTION

The frequency distribution of stellar masses at birth is called initial mass fuction, IMF. That is the number of stars formed in unit time in unit logarithmic interval of masses. The IMF is a most important tool in the study of star formation processes as well as the evolution of the Galaxy, particularly in evolutionary or population synthesis modeling of galaxies.

The first systematical investgation of IMF by Salpter(1955) was found a power low approximation to the IMF with a slope of -1.35 for stars in the solar neighbourhood and in the mass range 1 to $10 m_\odot$. Subseqently, this emprical law has been challenged by various authors. Especially Miller and Scalo(1979) and Scalo(1986) suggest the variation of the slope with mass as -(1 + *log*m) and Gutsten and Mezger(1983) and Larson(1986) propose the bimodal IMF - one peak represents the arm population and the other the interarm population.

Besides those,various authors(Garmany et al. 1982; Vanbeveren 1984; Rana 1987) suggested somewhat different present day mass function(PDMF) from the one suggested by Miller and Scalo for massive portion as well as lower mass end of PDMF.

However, IMF has been assumed to be constant with time. But there is no priori justification of that assumption. The IMF is actually a conditional probability whose form may depend on metal abundance, gas density, or some other property of the interstellar medium and some of these properties have varied with time and position in the Galaxy.

The information on subdwarf IMF would yield valuable clues concerning any dependence of the IMF on physical conditions, especially metal abundance.

Mould(1982) has compared the LFs of Schmidt(1975), Chiu(1980: SA57, SA 68), Eggen(1981) and that from the sample of Fenkart(1977). Although the results were rather discordant, he did a straight-line fit to Eggen(1981)'s data together with the Gunn and Griffin(1979) mass-lunimosity relation and found an identical halo IMF to the Salpter function. A similar comparison by Reid(1984) gave a suggestion that the halo IMF is marginally steeper than the disk IMF. Scalo(1986) compared the IMF of halo and disk field stars derived by Eggen(1983) and his disk IMF, and concluded that there is no indication of a metallicity-dependence of the IMF. However Eggen(1987) 's disk and halo LFs do not seem to give identical IMFs for lower masses. Therfore the quetion of metal-dependance of IMF for field stars has not yet been solved.

Moreover IMFs for globular clusters(Da Costa 1982) appear to steepen in sequence according to their metallicity. The graphic comparison of the IMFs of globular clusters from various sourses by Scalo (1986) implies that the IMF becomes more depleted in low-mass stars with decreasing metal abundance. Although he prefered the cause of the differences in IMFs is due to statistical and systemtic errors, stochastic IMF differences between clusters rather than a metal abundance effect, the question of major IMF variations between different clusters remains unsolved.

In this study, we would like to derive the subdwarf IMF by reestimating the subdwarf luminosity function. Lee(1991) has been derived Subdwarf luminosity function on the basis of the LHS catalogue proper motion stars utilized reduced proper motion diagram for selection of subdwarfs and mean absolute magnitude method to estimate the distance of stars and V/V_m method to get the luminosity function. However the distance derived by the mean absolute magnitude method is not accurate for the individual stars, therefore we will redrive the luminosity function with more accurate distance of stars estimated by the photometric parallexes.

Subdwarfs in this study should be referred more accurately as non-(current) disk stars (Eggen 1987) since they may be the halo stars as well as "thick disk" stars. It will be confirmed that they are neither disk stars nor old disk stars, but will not be attempted to distingush them between halo and thick disk stars. Because a definite criterion for each group is still on debate and the sample of this study is not large enough to divide them into each group.

In section 2, the initial mass function(IMF) of subdwarfs will be derived with the new derivation of subdwarf luminosity function by adopting the mass luminosity relation for subdwarfs. Subdwarf IMF is compared with disk IMF in section 3, followed by conclusion of section 4.

II. INITIAL MASS FUNCTION OF SUBDWARFS

A primary method for estimating the stellar mass function is to determine stellar luminosity function and convert this to a mass distribution using an adopted mass-luminosity relation. Unlike disk stars,the present mass function for subdwarfs directly reflect the IMF of them since the core hydrogen burning life time of the brightest one is about the age of the Galaxy. So far we have konwn that the halo is formed within a short time interval of 10^9 year order. According to Scalo(1986) notation, the total stellar birth rate per unit volume at time t $B(t)$ can be assumed to be constant.

In following sections, the determination of the luminosity function of subdwarfs and an adopted mass-luminosity relations will be discussed. The details of procedures can be referred the paper of Scalo(1986).

II.1 Luminosity Function of Subdwarfs

(a) Sample of Subdwarfs

Although the subdwarfs are known as field population II stars, the scarcity of them in the solar neiborhood and no clear-cut criterion make it difficult to derive the luminosity function of them. These "Population II" stars have known to have large velocity dispersions and small metal abundances relative to disk stars. A kinematic criterion, such as a minimum transverse velocity or minimum orbital eccentricity inferred from radial and transverse velosities usually depends on an assumed model for the velocity distribution function and rotational velocity of the halo, which was demonstrated clearly by Richstone and Graham(1981). Spectrophotometric criteria based on the different metal abundances in disk and halo stars are less fundamental because metal abundances are difficult to estimate and because they must be based on a model for the poorly-understood chemical evolution of the galaxy as emphasized by Mould(1982).

Schmidt(1975) first attemped to construct a luminosity function for the halo stars. Unfortunately among his sample of 121 stars, only 18 halo stars are left after adopting a kinematic criteria of $V_t > 250km/sec$. That was not enough to derive a reliable luminosity function, but enough to estimate their total mass density, which is of importance for understanding the dynamics of the halo population and its possible stability of the disk.

Later Chui(1980), Eggen(1983, 1987), Reid(1984), Lee(1985, 1991), Dawson(1986) investigated it by various

Table 1. Trigonometric Parallax Subdwarfs

LHS	π(err)	B-V	$M_v(\pi)$	$M_v(\pi$-cor)	M_v(cal)	δM_v
21	0.052(4)	0.88	7.10	7.03	7.99	-0.96
44	0.109(4)	0.75	6.64	6.62	7.06	-0.44
52	0.041(4)	0.85	7.49	7.38	7.78	-0.40
53	0.041(4)	0.78	7.16	7.05	7.28	-0.23
61	0.057(7)	1.44	10.18	10.16	10.46	-0.30
241	0.045(3)	0.62	6.57	6.52	5.99	0.53
393	0.060(4)	0.76	5.50	5.45	7.13	-1.68
405	0.052(6)	0.47	5.80	5.65	4.60	1.05
420	0.028(5)	0.54	4.54	4.04	5.27	-1.23
471	0.122(3)	1.00	11.68	11.67	8.73	2.94
490	0.035(6)	0.54	6.33	5.93	5.27	0.66
1231	0.033(6)	0.57	6.37	5.87	5.55	0.32
1599	0.025(4)	0.84	5.58	5.23	7.71	-2.48
2689	0.040(5)	0.62	6.76	6.61	5.99	0.62
2715	0.047(8)	1.20	9.19	8.77	8.84	-0.07
2914	0.068(6)	0.86	11.96	11.88	7.85	4.03
2953	0.034(4)	0.47	3.86	3.69	4.600	-0.91
3215	0.051(8)	0.75	8.14	7.79	7.06	0.73
3640	0.041(6)	0.51	5.42	5.12	4.99	0.13
3767	0.028(5)	0.92	6.46	5.96	8.25	-2.29

approaches and gave no unique conclusive shape of the luminosity function for subdwarfs. As Scalo(1986) discussed in detail, the fundamental problem lies in the criterion of subdwarf or halo stars. Eggen(1987) defined a halo, (more accurately) a non-(current) disk star by $[Fe/H] < -0.6$ and eccentricity $EC > 0.5$, and when $EC > 0.5$, it is assumed that $[Fe/H] < -0.6$.

Therefore, we use the Eggen(1987)'s criteria $[Fe/H] < -0.6$ and orbital eccentricity $EC > 0.5$ and $\delta(U-B) > 0.13$ to confirm the subdwarfs(Lee 1991) which were selected on the base of the reduced proper motion diagram(RPMD) by Chui(1980)'s criteria. If there is no such information, radial velocity larger than 65 km/sec and tangential velocity larger than 130 km/sec are applied. Among the 148 originally selected subdwarfs, 108 stars are confirmed to be subdwarfs.

(b) Absolute magnitude of subdwarfs

As discussed by Carney(1979), the Hyades and the most metal-poor halo dwarfs differ by about 1.6 mag in M_v at equal $B - V$ color indices. His result of $(M_v, B - V)$ relation for subdwarfs, $M_v = 5.14(B - V) + 2.81$ over the range $0.37 < (B - V) < 0.87$, was derived from the known trigonometric parallaxes of 8 subdwarfs. However Vandenberg(1983)'s isochrones lies below the field subdwarfs if Carney's color luminosity relation is used. Later Dawson(1986) used a set of isochrones of VandenBerg for $[Fe/H] = -1.77, Y = 0.2, Y = 0.3$, and ages of 12, 15, 18, and 21 Gyr with incorporating model atmosphere(Kurucz 1979) to get the relation of $(M_v, B - V)$, $M_v = 6.00(B - V) + 2.45$ over the range $0.45 < (B - V) < 0.80$. A more elaborately derived color-lunimosity relation for subdwarfs is that of Laird et al.(1988), which is $M_v = 4.60(B - V) + 3.46 + 1.67(\delta - 0.25)$.

However the sample subdwarf of this study covers to $(B - V) = 1.2$ and among the sample, 19 subdwarfs have available trigonometric parallaxes with $\sigma/\pi < 0.20$. LHS 61, which has a good trigonometric parallax measurement, is also included, even though it is redder than the sample stars. Therefore we derived the following $(M_v, B - V)$ relation from these 20 parallax available subdwarfs with Lutz and Kelker(1974) corrections (Table 1.).

$$M_v = -0.910 + 13.587(B - V) - 3.952(B - V)^2$$

is shown in Figure 1 and the absolute magnitude derived from the parallax minus the calcurated one by this relation for calibration stars are plotted in Figure 2 along the $(B - V)$ color. For calibration stars, trigonometric parallax, (B-V) color, $M_v(\pi)$, $M_v(\pi$-corrected), M_v(calculated), and δM_v are listed in Table 1. The $M_v(\pi$-corrected) is corrected according to Lutz and Kelkr(1974), while M_v(calculated) is the one derived by the above relation. The δM_v is $M_v(\pi$-corrected) minus M_v(calculated).

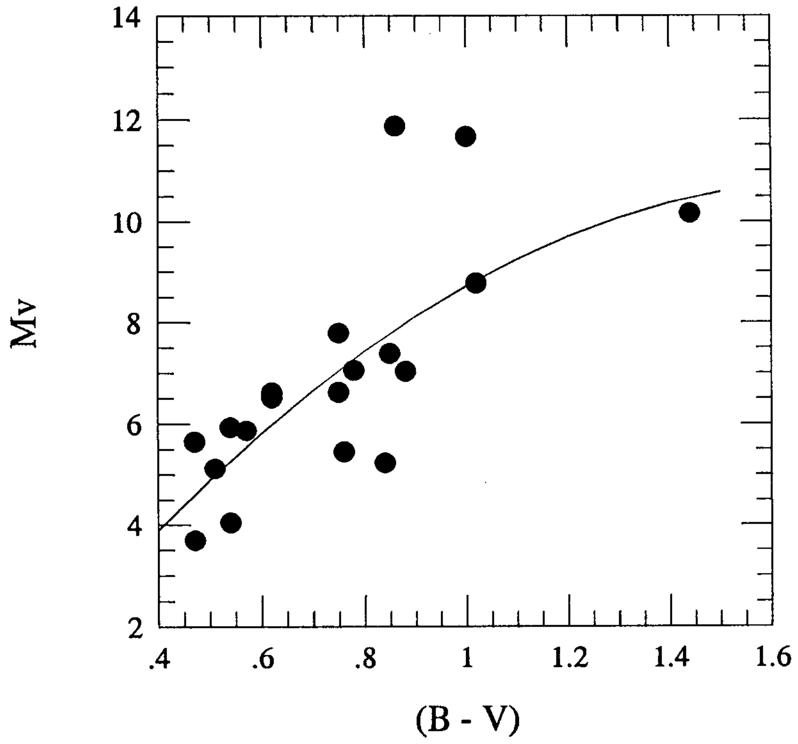

Fig. 1. Color-Magnitude Relation

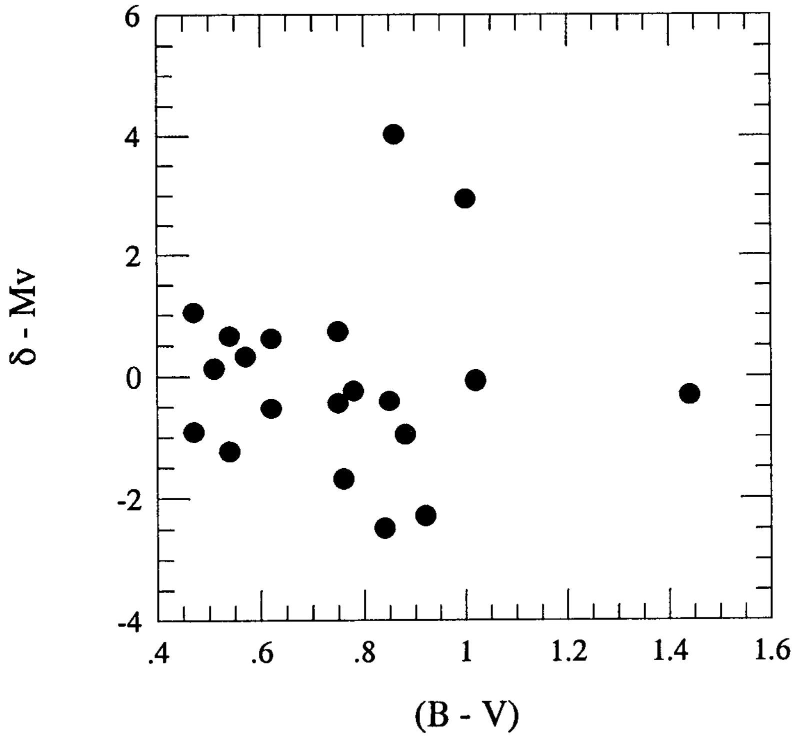

Fig. 2. δMv = Mv(π - corrected) - Mv(calculated) versus Color

The absolute magnitude of sample subdwarfs derived by the above relation is compared with that by other color luminosity relations. Since there is not enough $(b-y)$ and $(R-I)_k$ colors available for these trigonometric parallax subdwarfs, the $(M_v, b-y)$ relation for halo stars, $M_v = 10.024(b-y)+2.02+1.67(\delta-0.25)$ of Laired et al.(1988) and the $(M_v,(R-I)_k)$ relation of Dawson's table for subdwarfs are used to compare the absolute magnitudes derived by different colors. Figure 3a, 3b are plots of the absolute magnitudes differeces versus $(B-V)$ and $(b-y)$ color respectively. The difference of the absolute magnitude is the magnitude derived by $(b-y)$ minus that by $(B-V)$ color. For estimation of the absolute magnitude by $(M_v, b-y)$ relation the third term, correction for the metal poorest stars was ignored for stars in this figures. That means we assumed they are average halo stars. However the facts that the adopted $(M_v, B-V)$ relation is quadratic and the $(M_v, b-y)$ relation is linear is reflected in the difference between the absolute magnitudes estimated by those relations as some systematic difference between two. However the average of difference is about 0.40 with deviation of 0.56. Figure 4a and 4b are same plots for comparison of the absolute magnitudes derived by $(R-I)_k$ color. There is no systematic difference, but the average of difference is -0.28 with deviation of 0.81. So we take the absolute magnitude estimated by $(M_v, B-V)$ relation whenever there is no other colors while if there is either $(b-y)$ or $(R-I)_k$ color available, $(M_v, b-y)$ relation of Laird et al.(1988) or $(M_v,(R-I)_k)$ relation of Dawson(1986) is used to estimate the absolute magnitudes and then the average of the estimated magnitues is adopted for sample stars. They are listed in the Table 2 with sample's V magnitude and proper motion μ.

With this absolute magnitude, tangential velocity of the each sample star is calculated. The median tangential velocity is 236 km/s and the average tangential velocity is found to be 256 km/s. This implies the contamination of the disk stars is negligible in this sample of subdwarf.

(c) Derivation of Luminosity Function by V/Vm Method

The V/V_m method is applied to this sample of subdwarfs. This method was formulated by Schmidt(1968) for quasar statistics and later applied to the stellar luminosity functions(Schmidt 1975; Chui 1980; Eggen 1983, 1987; Lee 1991).

The sample of subdwarfs are limited by the proper motion larger than 0.5" of arc per year and by the apparent magnitude of ~ 20. Therefore the smaller one of the maximum distance limits is set either by the proper motion limit of 0.5" of arc per year ($r_m = \mu \cdot r/0.5$) or by the apparent visual magnitude limit of 20 ($r_m = dex[0.2(20-m_v)] \cdot r$). It is found that the smaller limit of the maximum distance is set by the proper motion limit.

The LHS catalog covers northern sky of the $\delta > -33^o$ and the region of $b < 10^o$ is excluded by author because of heavy obscuration for proper motion measurement. The sample stars cover the 64.8% of the sky.

For each star, $V_m = A \cdot r_m^3$ is calculated, where A is $4/3 \cdot \pi\omega$. Since the ω is the sky covered by the sample, $V_m = 4/3 \cdot \pi \cdot 0.648 \cdot r_m^3$ is calculated.

The luminosity Function for subdwarfs is determined by the summation of $1/V_m$, $\sum V_m^{-1}$ for each absolute magnitude. The completeness of the sample is tested by the average of V/V_m which varies from 0.32 for $M_v = 6.5$ to 0.55 for $M_v = 4.5$ giving an overall average of 0.44. The V/V_m, distance r, $1/V_m$, and tangential velocity for the sample stars are also listed in Table 2.

The present result of the luminosity function for subdwarfs is plotted with previous ones(Chiu 1980; Eggen 1983, 1987; Lee 1991) in the Figure 5. Present result is found to be good agreement with that of Eggen(1987) except the last faint point.

(d) Mass-Luminosity Relation for subdwarfs

The mass-M_v relation for Population II stars was given by Gunn and Griffin(1979), which was based on the Veeder's(1974) $M_{bol}-(V-K)$ diagram and bolometric correction, and a theoretical mass-M_{bol} relation taken from Copeland, Jensen, and Jorgensen(1970) for a metal abundance $Z = 10^{-4}$, extrapolated from m = 0.25m$_\odot$ to m = 0.1m$_\odot$.

Dawson(1987) assumed that subdwarfs brighter than $M_v = 5$ have m = 0.65 m$_\odot$ and estimated the masses for faint stars of $M_v = 12$ from the VandenBerg et al.(1983) models and took m = 0.1 m$_\odot$ at $M_v = 14$ to get the

Table 2. Sample Subdwarfs

LHS	V	μ(arcsec)	M_v	V/V_m	r(pc)	$1/V_m$	V_t(km/s)
21	8.52	2.204	7.60	0.012	15.31	1.20e-6	160
44	6.45	7.042	6.80	0.000	8.51	2.14e-7	284
52	9.43	3.681	7.55	0.003	23.76	6.89e-8	415
53	9.10	3.681	7.05	0.003	25.70	5.44e-8	449
61	11.48	2.251	10.46	0.011	16.00	9.87e-7	171
152	13.16	1.020	9.10	0.118	64.71	1.60e-7	313
174	12.75	1.560	10.61	0.033	26.79	6.31e-7	198
187	10.00	1.093	8.61	0.096	18.97	5.17e-6	98
195	9.86	1.486	6.16	0.038	54.83	8.52e-8	386
232	13.72	1.022	9.49	0.117	70.14	1.25e-7	340
241	8.30	1.973	6.17	0.016	26.73	3.14e-7	250
312	9.92	1.036	5.37	0.112	81.47	7.66e-8	400
327	12.67	1.013	8.67	0.120	63.24	1.75e-7	304
347	12.45	1.140	9.25	0.084	43.55	3.76e-7	235
405	7.22	1.187	5.20	0.075	25.53	1.69e-6	143
420	7.30	1.467	5.46	0.040	23.39	1.14e-6	163
471	11.25	1.635	8.72	0.029	31.99	3.22e-7	248
490	8.61	1.205	5.51	0.071	41.78	3.61e-7	239
537	9.96	1.301	6.66	0.057	45.60	2.21e-7	281
540	8.19	1.282	4.98	0.059	43.85	2.59e-7	267
1004	11.28	0.696	8.24	0.371	40.46	2.06e-6	134
1041	14.35	0.617	8.18	0.532	171.40	3.90e-8	501
1112	9.25	0.545	4.88	0.772	74.99	6.75e-7	194
1138	13.29	0.612	8.72	0.545	81.85	3.67e-7	237
1365	9.08	0.996	5.71	0.127	47.10	4.46e-7	222
1368	12.59	0.508	7.50	0.953	104.23	3.10e-7	251
1432	8.02	0.603	5.67	0.570	69.34	6.30e-7	198
1501	8.06	0.820	5.06	0.227	39.81	1.32e-6	155
1526	13.05	0.577	9.30	0.651	56.23	1.35e-6	154
1527	13.45	0.632	8.53	0.495	96.61	2.02e-7	289
1533	9.68	0.715	7.78	0.342	23.93	9.19e-6	81
1545	10.78	0.756	5.18	0.289	131.81	4.65e-8	472
1644	9.26	0.538	4.61	0.803	85.1	4.80e-7	217
1646	10.60	0.659	6.78	0.437	57.94	8.28e-7	181
1695	12.63	0.650	8.78	0.455	58.88	8.22e-7	181
1718	12.46	0.505	8.12	0.971	73.96	8.84e-7	177
1725	12.23	0.659	9.30	0.437	38.55	2.81e-6	120
1732	14.81	0.550	9.20	0.751	132.13	1.20e-7	345
1800	14.74	0.784	9.78	0.259	97.95	1.02e-7	364
1841	13.18	0.900	8.72	0.171	77.80	1.34e-7	332
1919	13.71	0.551	9.20	0.747	79.62	5.46e-7	208
1934	10.16	0.883	7.85	0.182	28.79	2.75e-6	121
2000	9.76	0.641	4.70	0.475	102.80	1.61e-7	312
2036	9.65	0.608	4.83	0.556	92.05	2.63e-7	265
2056	11.26	0.610	6.98	0.551	71.78	5.49e-7	208
2080	10.67	0.531	4.00	0.835	216.27	3.04e-8	544
2082	9.69	0.775	4.70	0.269	99.54	1.00e-7	366
2169	10.48	0.528	4.33	0.849	169.82	6.39e-8	425
2194	8.30	0.876	4.47	0.186	58.21	3.48e-7	242
2278	15.59	0.502	9.30	0.988	181.13	6.13e-8	431
2284	12.39	0.635	8.31	0.488	65.61	6.37e-7	198
2308	10.22	0.845	4.90	0.207	116.14	4.87e-8	465
2318	8.22	0.554	4.70	0.735	50.58	2.09e-6	133
2365	11.39	0.773	6.82	0.271	81.85	1.82e-7	300
2373	9.76	0.522	4.20	0.879	129.42	1.49e-7	320
2424	11.53	0.630	6.34	0.500	109.40	1.41e-7	327
2450	10.36	0.532	4.70	0.830	135.52	1.23e-7	342
2463	12.49	0.718	8.89	0.338	52.48	8.61e-7	179
2467	12.26	0.980	8.37	0.133	59.98	2.27e-7	279
2507	9.25	0.606	5.82	0.562	48.53	1.81e-6	139
2647	8.37	0.859	5.27	0.197	41.69	1.00e-6	170
2669	8.04	0.550	5.50	0.751	32.21	8.29e-6	84
2701	12.94	0.582	8.18	0.634	89.54	3.26e-7	247
2708	12.64	0.506	8.37	0.965	71.45	9.75e-7	171
2715	10.83	0.652	8.84	0.451	25.06	1.06e-5	78
2780	13.26	0.721	7.28	0.334	156.68	3.20e-8	535
2846	11.57	0.784	7.06	0.259	79.98	1.87e-7	297
2872	10.68	0.574	5.95	0.661	88.11	3.56e-7	240
2914	12.80	0.543	7.85	0.781	97.72	3.08e-7	252
2943	14.90	0.598	9.25	0.585	134.59	8.84e-8	382

Table 2. Continued

LHS	V	μ(arcsec)	M_v	V/V_m	r(pc)	$1/V_m$	V_t(km/s)
2953	6.20	0.945	4.87	0.148	18.45	8.69e-6	83
2956	13.15	0.558	7.90	0.719	112.20	1.88e-7	297
2962	12.13	0.879	8.72	0.184	47.97	6.14e-7	200
2968	10.43	0.864	6.74	0.194	54.58	4.39e-7	224
2969	11.52	0.501	6.04	0.994	124.74	1.89e-7	296
3008	8.58	0.759	5.48	0.286	41.59	1.46e-6	150
3034	12.33	0.839	7.17	0.212	107.65	6.25e-8	428
3035	13.35	0.539	7.13	0.798	174.99	5.49e-8	447
3051	13.62	0.578	8.18	0.647	122.46	1.30e-7	336
3052	13.81	0.784	8.18	0.259	133.66	4.00e-8	497
3070	14.35	0.537	8.18	0.807	171.40	5.91e-8	436
3164	11.90	0.715	8.55	0.342	46.77	1.23e-6	159
3184	9.77	0.659	5.82	0.437	61.66	6.87e-7	193
3215	9.60	0.704	7.06	0.358	32.28	3.92e-6	108
3222	10.36	0.581	8.46	0.637	23.99	1.70e-5	66
3304	8.38	0.604	5.73	0.567	33.88	5.37e-6	97
3312	8.41	0.988	5.64	0.130	35.81	1.04e-6	168
3336	12.56	0.655	8.43	0.445	69.99	5.45e-7	208
3357	12.53	0.511	8.49	0.937	64.12	1.31e-6	155
3364	11.46	0.505	5.94	0.971	103.28	3.25e-7	247
3366	10.43	0.803	6.90	0.241	50.82	6.78e-7	193
3397	13.95	0.564	9.66	0.697	72.11	6.85e-7	193
3408	13.90	0.567	7.97	0.686	153.81	6.95e-8	413
3427	9.64	0.764	6.08	0.280	51.64	7.50e-7	187
3550	8.37	0.559	5.17	0.716	43.65	3.17e-6	116
3579	13.76	0.562	7.92	0.704	147.23	8.13e-8	392
3640	7.36	0.903	5.26	0.170	26.30	3.44e-6	113
3731	11.10	0.739	6.08	0.310	100.92	1.11e-7	354
3770	9.48	0.508	4.76	0.953	87.90	5.17e-7	212
3838	9.52	0.603	7.21	0.570	28.97	8.64e-6	83
3847	11.50	0.778	6.42	0.265	103.75	8.76e-8	383
3867	13.41	0.575	9.66	0.658	56.23	1.36e-6	153
3869	11.50	0.557	7.71	0.723	57.15	1.43e-6	151
3897	12.95	0.715	8.78	0.342	68.23	3.97e-7	231
3989	13.00	0.701	7.10	0.363	151.01	3.88e-8	502
4005	10.10	0.595	6.58	0.593	50.47	1.70e-6	142
4037	13.52	0.764	7.52	0.280	158.49	2.60e-8	574

polynomial fit of

$$log(m/m_\odot) = 0.4038 - 0.1840M_v + 0.01704M_v^2 - 7.88810^{-4}M_v^3$$

for the subdwarf mass-luminosity relation.

Both mass-M_v relations are applied for the sample stars. However if we use Scalo's definition of mass function, the scale height is reqired. According to Schaifers and Voigt(1982), the mean absolute distance of subdwarfs with $\delta(U-B) > 0.15$ from the galactic plane in the vicinity of the sun is 2000 pc. Therefore initial mass function is estimated by

$$\phi_{ms}(logm) = \psi_{LF}(M_v) \cdot \left(\frac{dM_v}{dlogm}\right) \cdot 2H$$

by taking scale height of 2000 pc and listed in Table 3. In the Table 3, the luminosity function, $log\psi(M_v) + 10$, is listed in the second column and $logm$, $dM_v/dlogm$, and log F which is $log\phi(logm)$ for Gunn and Griffin's relation and Dawson's are list in the columns of the third to fifth, and the sixth to eighth respectively.

III. COMPARISON WITH DISK INITIAL MASS FUNCTION

In order to find the change of the initial mass function with time or with metallic abundance, the disk initial mass function and the halo initial mass function should be compared. Since the halo IMF is derived in the masses less than 0.7 $m_\odot$ in this study, the present day mass function of disk stars less than one solar mass, can be used for

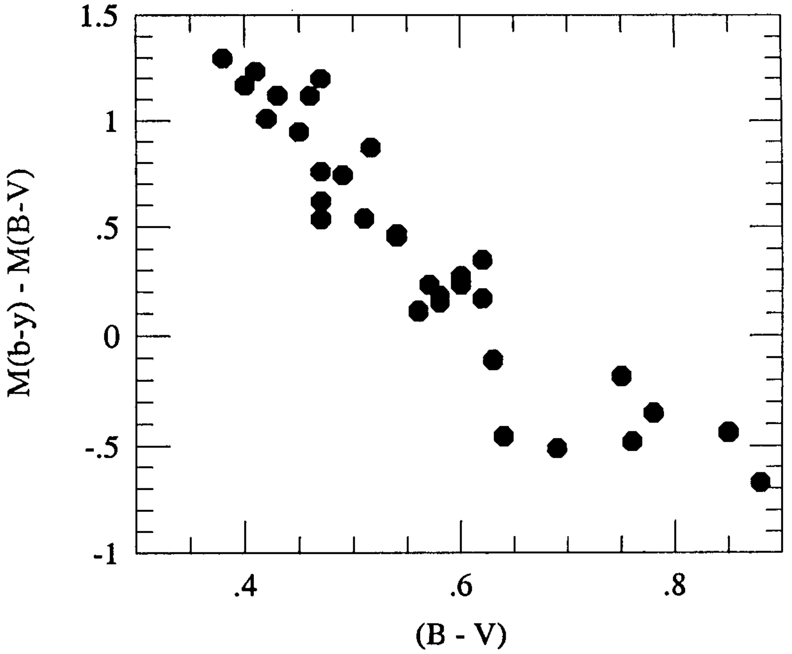

Fig. 3a. Magnitude Difference, M(b-y) minus M(B-V), versus (B-V)

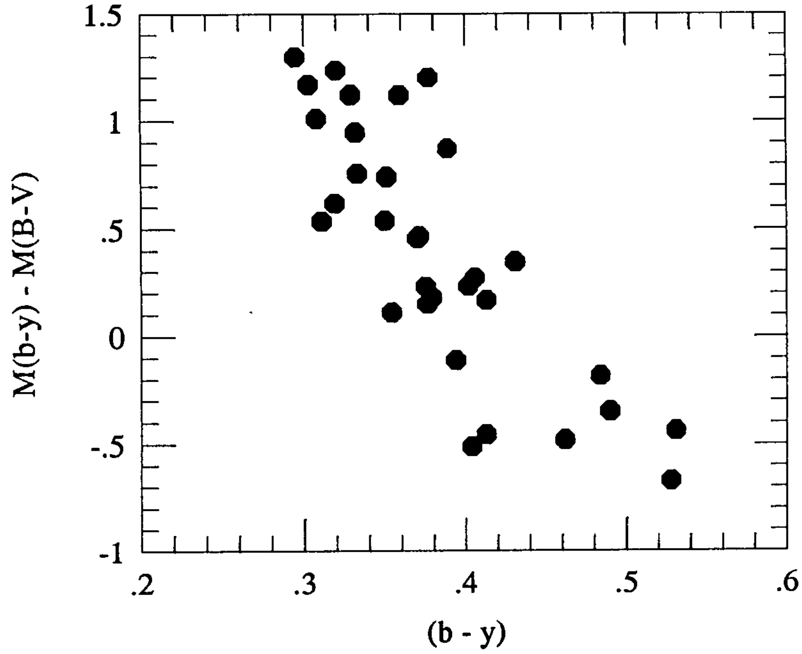

Fig. 3b. Magnitude Difference, M(b-y) minus M(B-V), versus (b-y)

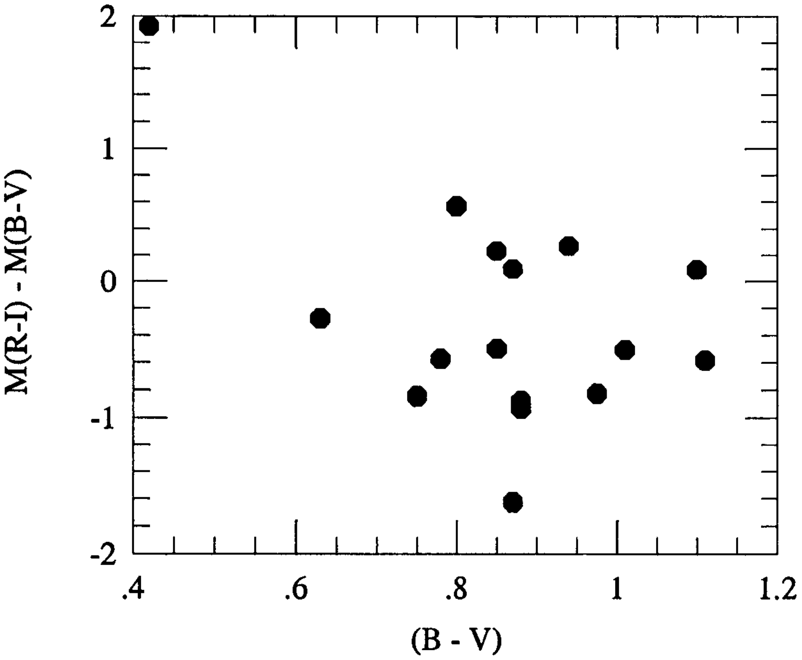

Fig. 4a. Magnitude Difference, M(R-I) minus M(B-V), versus (B-V)

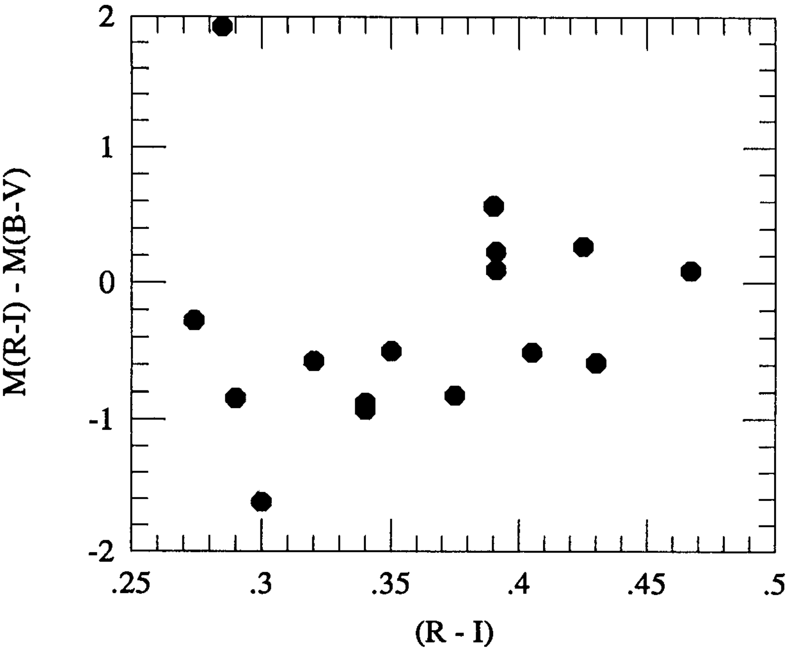

Fig. 4b. Magnitude Difference, M(R-I) minus M(B-V), versus (R-I)

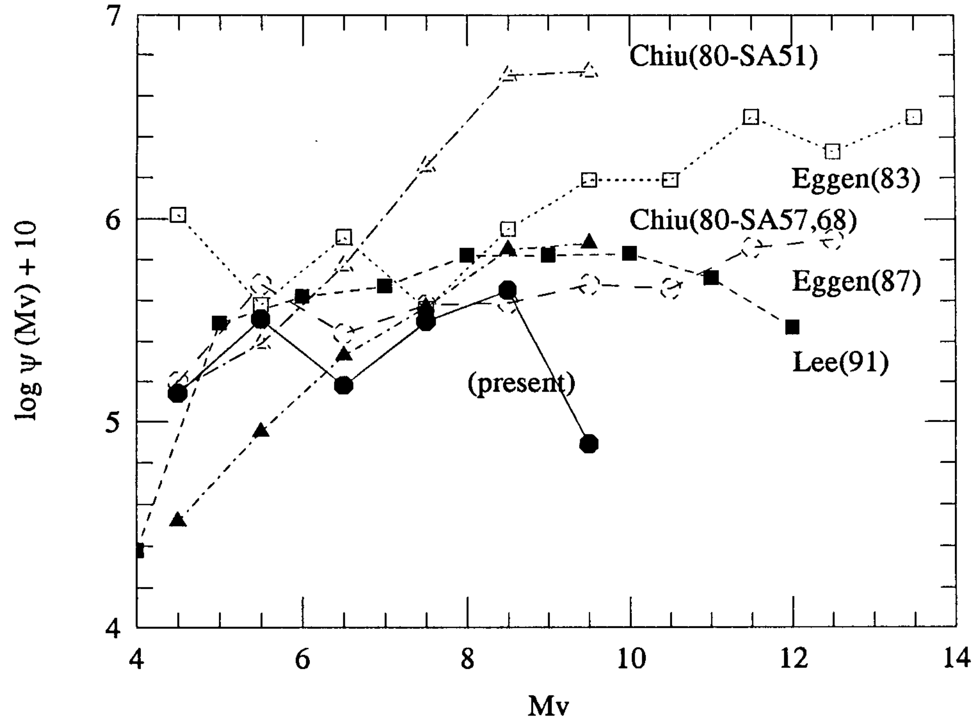

Fig. 5. Subdwarf Luminosity Function. Present work is marked by filled circle with solid line, Chiu(1980, SA51)'s by open triangle with long dashed and dotted line, Chiu(1980, SA57 & SA68)'s by filled triangle with short dashed and dotted line, Eggen(1983)'s by open square with dotted line, Eggen(1987)'s by open circle with long dashed line, Lee(1991)'s by filled square with short dashed line respectively.

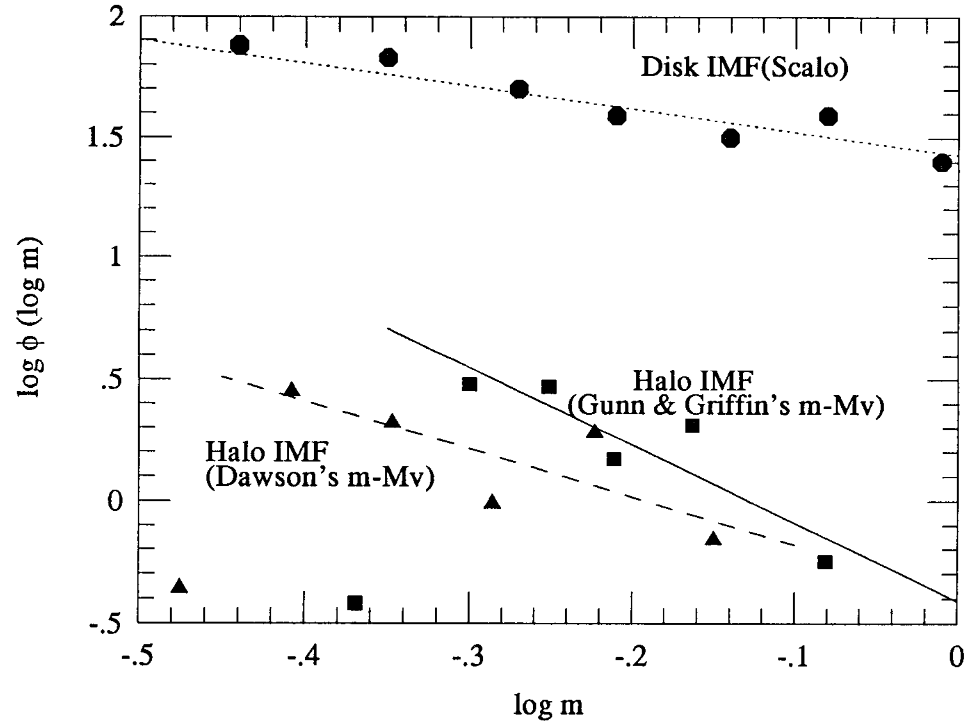

Fig. 6. Initial Mass Function. Halo IMF derived with Gunn and Griffin's mass-luminosity relation is marked by filled square and solid line, that with Dawson's relation by filled triangle and long dashed line respectively. Disk IMF of Scalo is marked by filled circle

Table 3. Initial Mass Function

M_v	LF + 10	log m	dM_v/dlog m	log F	log m	dM_v/dlog m	log F
4.5	5.14	-0.081	10.1	-0.25	-0.150	12.6	-0.16
5.5	5.51	-0.163	16.1	0.31	-0.223	14.9	0.28
6.5	5.18	-0.211	24.4	0.17	-0.268	16.1	-0.01
7.5	5.50	-0.251	23.8	0.47	-0.347	16.7	0.32
8.5	5.65	-0.300	16.9	0.48	-0.408	15.6	0.45
9.5	4.89	-0.369	12.2	-0.42	-0.475	14.1	-0.36

comparison. Because their lifetime of Main Sequence is long enough to have been accumulated since disk formed. Therefore we use Scalo's (1986) disk IMF for comparison.

Our result of halo luminosity function is consistent with our previous result with a slight systematic shift toward the lower values, which was derived with the almost same sample of data with only difference of the distance estimation by the mean absolute magnitude method. Although it covers only a portion of the luminosity range of Eggen's halo luminosity function(1987), present result dose not much differ from that of Eggen(1987). For two cases, the same method is adopted for derivation of luminosity function, but the sample stars are different. Since our sample stars were confirmed not to be included the disk stars, the derived luminosity function can be presumed to be minimum.

Since the halo mass luminosity relations of Gunn and Griffin(1979) and Dawson(1986) are slightly different each other, both relations are adopted to the dereived halo luminosity function to get halo initial mass function seperately. Those halo initial mass functions are compared with the Scalo's disk present day mass function. Figure 6 is a plot of halo IMFs, by Gunn and Griffin's mass-luminosity relation(solid line) and Dawson's relation(dashed line), and of disk IMF(dotted line). As seen in Figure 6, the halo IMFs give the indices of mass spectrum, -3.2(Gunn and Griffin's mass-luminosity relation), -2.0(Dawson's mass-luminosity relation) respectively if the samllest mass point is ignored. Both indices are smaller than that of Salpter's, -1.5 and even more smaller than that of disk IMF of Scalo, -0.9 of this mass range. Therefore we can say that the halo IMF is steeper than that of disk IMF in this small mass range and the IMF has been changed with time and metallicity.

IV. CONCLUSION

Although the field halo IMF has been thought to be identical to the Salpter function(Mould 1982) or marginally steeper than the disk IMF (Reid 1984) or identical to the disk IMF(Scalo 1986), the question of metal-dependence of IMF has not been solved. Fundamentally, the fact that the IMF is a conditional probability, makes constant IMF artificial. Moreover for globular clusters, IMFs appear to steepen in sequence according to their metallicity. Of course, the cause of these has not yet confirmed yet, varing IMF is to be more probable and natural.

The present study shows that the halo IMF is quite different from the disk IMF in the small mass range, although it did not give the definite halo IMF, because of some uncertainty in mass-luminosity relation for halo stars. Since the mass range covered in this study is small, one may consider this portion as a small fluctuation portion of the entire small mass range. But it seems not the case. Rather than it seems that IMF has been changed. But we need further data for fainter and redder subdwarfs to confirm this conclusion.

As a summary, in this study the halo stars are selected on the bases of proper motion utilizing the reduced proper motion diagram and confirmed individual stars with $[Fe/H] < -0.6$ and orbital eccentricity $EC > 0.5$ and $\delta(U-B) > 0.13$ or radial velocity$V_r > 65km/s$ or tangential velocity $V_t > 130km/s$. From this sample of subdwarfs, halo luminosity function is derived with photometric parallaxes and V/V_m method. With Gunn and Giffin's as well as Dawson's mass-luminosity relations for halo stars, the halo IMFs are estimated and compared with disk IMF of Saclo to find the difference between halo and disk IMFs in the region of the small mass.

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