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TOTAL NUMBER OF PLANETARY NEBULAE IN DIFFERENT GALAXIES AND THE PN DISTANCE SCALE

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RESUMEN

A partir de una muestra de quince galaxias se encuentra que la tasa de natalidad de nebulosas planetarias por unidad de luminosidad, $\dot{\xi}$, disminuye al aumentar la luminosidad y al aumentar $(B-V)_0$. Se discuten posibles explicaciones para estos resultados. Se estima el valor de $\dot{\xi}$ para la Galaxia y a partir de él se encuentra que el número total de nebulosas planetarias en nuestra galaxia con R $\leq$ 0.64 pc es de 7200 $\pm$ 1800. El valor galáctico de $\dot{\xi}$ implica que la mayoría de las estrellas de masa intermedia pasa por la etapa de nebulosa planetaria. El valor galáctico de $\dot{\xi}$, la tasa de mortalidad estelar por unidad de luminosidad y la tasa de natalidad de enanas blancas favorecen escalas de distancias largas para nebulosas planetarias, como la de Cudworth (1974) y la de Mallik y Peimbert (1988).

ABSTRACT

From a sample of fifteen galaxies it is found that the birth rate of PN per unit luminosity, $\dot{\xi}$, decreases with increasing luminosity and with increasing $(B-V)_0$; possible reasons for these relationships are discussed. The $\dot{\xi}$ value for the Galaxy is estimated and, from it, a total number of PN of 7200 $\pm$ 1800 with R $\leq$ 0.64 pc is obtained. The galactic $\dot{\xi}$ value implies that most of the intermediate mass stars go through the PN stage. The galactic $\dot{\xi}$ value, the stellar death rate per unit luminosity and the white dwarf birth rate are in favor of long distance scales to PN like those of Cudworth (1974) and Mallik and Peimbert (1988).

Key words: **NEBULAE-PLANETARY – STARS-EVOLUTION – STARS-STELLAR STATISTICS**

I. INTRODUCTION

In the last ten years Jacoby and collaborators have made estimates of the birth rate and total number of PN in sixteen galaxies (Jacoby 1980, 1989; Jacoby *et al.* 1989, 1990; Ciardullo *et al.* 1989a, 1989b). This seminal work can be used to study the following problems: a) the fraction of intermediate mass stars ($0.8 \leq M_i(M_\odot) \leq 8$, where M_i is the initial mass), that go through the PN stage, b) the relationship between PN birth rate and galaxy type, c) the relationship between PN birth rate and average age of the stellar population in a given galaxy and d) the constraints imposed by the PN birth rate and by the stellar death rate on the PN distance scale. In what follows we will study these problems.

II. BIRTH RATE AND TOTAL NUMBER OF PN

Table 1 presents for a group of galaxies: the color excess, $E(B-V)$, the intrinsic color index, $(B-V)_0$, the apparent blue magnitude, m_B, the bolometric correction, B.C., the distance modulus corrected for absorption, $m_0 - M$, and the absolute bolometric magnitude M_{bol}.

Table 2 presents the PN birth rate per solar luminosity, $\dot{\xi}$, and the total number of PN, N_T, for the galaxies in Table 1. The $\dot{\xi}$ values were derived assuming a mean PN lifetime of 25 000 years that, for a mean expansion velocity of 25 km s^{-1} (Phillips 1989), corresponds to a maximum radius of detectability, R_m, of 0.64 pc. The $\dot{\xi}$ values were taken directly from Jacoby and collaborators with the exception of those for: M31, M32, the

TABLE 1

COLOR INDICES, BOLOMETRIC CORRECTIONS, DISTANCE MODULI AND ABSOLUTE BOLOMETRIC MAGNITUDES

Object	$E(B-V)$	$(B-V)_0$	m_B	B.C.	m_0-M	M_{bol}	References[a]
NGC 4472	0.02	0.98	9.32	−0.85	30.71	−23.29	1,2,3,4
NGC 4486	0.02	0.97	9.62	−0.85	30.81	−23.08	1,3,4,5
NGC 4649	0.02	1.00	9.83	−0.85	30.76	−22.85	1,2,3,4
NGC 4406	0.02	0.96	10.02	−0.79	30.98	−22.78	1,2,3,4
NGC 4374	0.02	0.95	10.23	−0.83	30.98	−22.60	1,2,3,4
NGC 4382	0.02	0.88	10.10	−0.67	30.79	−22.31	1,3,4,5
M31	0.11	0.80	4.36	−0.80	24.26	−21.96	6,7,8
M81	0.09	0.84	7.87	−0.80	27.72	−21.88	9,10
NGC 3379	0.05	0.82	10.33	−0.84	29.96	−21.57	3,7,11
NGC 3384	0.07	0.84	10.70	−0.79	30.03	−21.25	3,7,11
The Galaxy	...	0.53:	...	...	...	−21.2:	12
NGC 3377	0.05	0.79	11.10	−0.74	30.07	−20.69	3,7,11
LMC	0.12	0.43	0.63	...	18.58	−19.0:	7,13
SMC	0.06	0.44	2.79	...	18.99	−17.2:	7,13,14
M32	0.09	0.85	9.15	−0.80	24.26	−17.14	6,7
NGC 205	0.09	0.75	8.85	−0.45	24.26	−16.99	6,7
NGC 185	0.12	0.78	10.07	−0.60	24.26	−16.07	6,7

a. 1) Burstein and Heiles 1984, 2) Poulain 1988, 3) Sandage and Tammann 1981, 4) Jacoby *et al.* 1990, 5) Michard 1982, 6) Ciardullo *et al.* 1989b, 7) de Vaucouleurs *et al.* 1976, 8) Freeman 1970, 9) Brandt *et al.* 1972, 10) Jacoby *et al.* 1989, 11) Ciardullo *et al.* 1989a, 12) de Vaucouleurs and Pence 1978, 13) Hindman 1967, 14) Peimbert and Torres-Peimbert 1976.

TABLE 2

BIRTH RATE AND TOTAL NUMBER OF PN

Object	$\dot{\xi}$ (10^{-12} yr^{-1} $L_\odot^{-1}$)	N_T (10^3)	References
NGC 4472	2.7 ± 0.6	11.1 ± 2.5	1,2
NGC 4486	3.4 ± 0.6	11.5 ± 2.0	1,2
NGC 4649	2.6 ± 0.8	7.1 ± 2.2	1,2
NGC 4406	5.4 ± 0.8	13.9 ± 2.1	1,2
NGC 4374	6.8 ± 1.3	14.8 ± 2.8	1,2
NGC 4382	8.0 ± 1.2	13.3 ± 2.0	1,2
M31	6.6 ± 1.2	8.0 ± 1.5	2,3
M81	8.4 ± 1.8	9.4 ± 2.0	2,4
NGC 3379	8.5 ± 1.7	7.2 ± 1.4	2,5
NGC 3384	15.0 ± 3.0	9.4 ± 1.9	2,5
The Galaxy	12.0 ± 3.0	7.2 ± 1.8	2
The Galaxy	...	9.1 ± 3.3	6
NGC 3377	15.0 ± 3.8	5.6 ± 1.4	2,5
LMC	12.6 ± 2.7	1.0 ± 0.25	2,6
SMC	19.2 ± 5.3	0.29 ± 0.08	2,6
M32	10.1 ± 2.5	0.14 ± 0.04	2,3
NGC 205	14.5 ± 4.2	0.18 ± 0.05	2,3
NGC 185	20.6 ± 10.3	0.11 ± 0.05	2,3

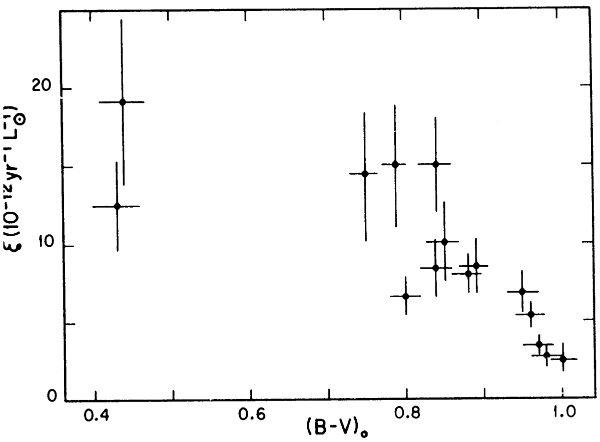
1) Jacoby et al. 1990, 2) this work, 3) Ciardullo et al. 1989b, 4) Jacoby et al. 1989, 5) Ciardullo et al. 1989a, 6) Jacoby 1980.

1C, the LMC and the Galaxy. For M31 the $\dot{\xi}$ value s obtained from: a solar bolometric absolute ıgnitude, $M(\odot)_{bol} = +4.75$ (Allen 1973), a B.C. of).8 mag and an estimated number of 970 PN for ·egion of M31 with $M_{bol} = -19.68$ (Ciardullo *et* 1989b). For M32 the $\dot{\xi}$ value is an average of the o values derived from the number of PN within 5 and 1.5 magnitudes of the maxium luminosity ınd by Ciardullo *et al.* (1989b). The $\dot{\xi}$ values for e SMC and the LMC were derived from the N_T lues by Jacoby (1980) and the M_{bol} values in Table The $\dot{\xi}$ value for the Galaxy was estimated from e ($\dot{\xi}$, M_{bol}) and the ($\dot{\xi}$, $B-V$) relations presented in gures 1 and 2. The N_T values were derived from e $\dot{\xi}$ values in Table 2 and the M_{bol} values in Table with the exception of the values for the SMC and e LMC.

In Figures 1 and 2 we show the $\dot{\xi}$ versus M_{bol} and e $\dot{\xi}$ versus $(B-V)_0$ values for the sample in Table excluding NGC 185 due to its large error and e Galaxy because it is an indirect determination. ·om Figure 1 it is found that there is a strong ırrelation between M_{bol} and $\dot{\xi}$, in the sense that e brighter the galaxy, the smaller the $\dot{\xi}$ value. ·om Figure 2 it is also found that there is a strong ırrelation between $(B-V)_0$ and $\dot{\xi}$ in the sense that .e redder the galaxy, the smaller the $\dot{\xi}$ value.

III. STELLAR DEATH RATE

It is possible to compare $\dot{\xi}$ with the stellar death ıte per solar bolometric luminosity, $\dot{S}$. Renzini and uzzoni (1986) computed $\dot{S}_b$ values as a function f time from models with a single burst of star ırmation, without subsequent star formation or ar accretion, and three widely different initial mass ınctions, IMF, independent of time and chemical



ig. 1. PN birth rate per solar luminosity, $\dot{\xi}$, versus bolo- ıetric magnitude, M_{bol}, for a group of fifteen galaxies.

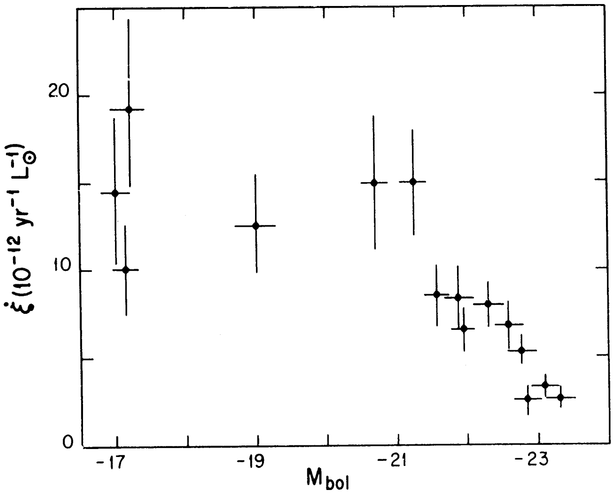


Fig. 2. $\dot{\xi}$ versus the intrinsic color index, $(B-V)_0$ for the sample in Figure 1.

composition. Their assumed IMF by number are given by: $\phi(M_i) = AM_i^{-\alpha}$, with α equal to 1.5, 2.35 and 3.5 for $M_i \geq 0.57\ M_\odot$ and $\alpha = 2.35$ for $M_i < 0.57\ M_\odot$ for the three IMF.

Figure 3 shows the $\dot{S}_b$ values as a function of time for the three IMF. Note that the $\dot{S}_b$ values are extremely insensitive to the population age or to the IMF. We will extend the results by Renzini and Buzzoni (1986) to systems with constant and decreasing rates of star formation.

For a system with a constant rate of star formation we can define a stellar death rate per unit luminosity as follows

$$\dot{S}_c(t_1) = \frac{\int_0^{t_1} \dot{S}_b(t)dt}{\int_0^{t_1} dt}, \tag{1}$$

where t_1 is the age of the system.

From the computations by Renzini and Buzzoni (1986) it can be seen that for $\alpha = 2$ and $10^7 \leq$ t(years) $\leq 10^{10}$

$$\dot{S}_b(t) \approx a \log t, \tag{2}$$

where a is a constant (see Figure 3). To a very good approximation from equations (1) and (2) it is obtained that

$$\dot{S}_c(t_1) = \frac{\dot{S}_b(t_1) \log(t_1/e)}{\log t_1}, \tag{3}$$

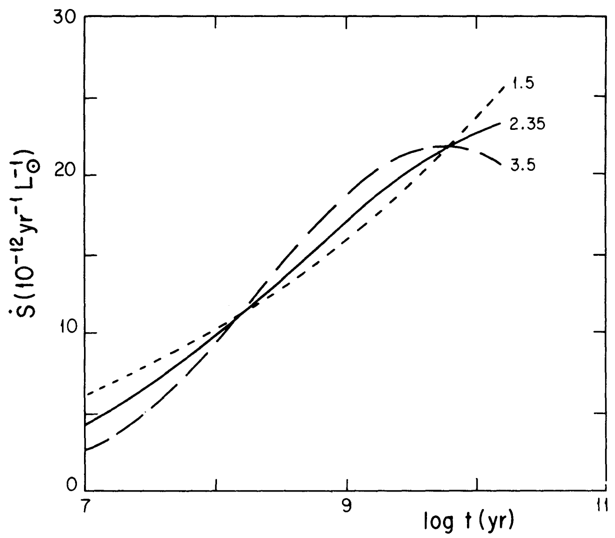


Fig. 3. Stellar death rate per solar luminosity, $\dot{S}$, versus age, for systems with three values of the IMF slope for M $\geq$ 0.57 $M_{\odot}$ and a single slope for M $<$ 0.57 $M_{\odot}$ given by α = 2.35 (from Renzini and Buzzoni 1986).

which, for $t_1 = 10^{10}$ years and $\dot{S}_b(10^{10}) = 21 \times 10^{-12}$ yr^{-1} $L_{\odot}^{-1}$, yields $\dot{S}_c(10^{10}) = 20 \times 10^{-12}$ yr^{-1} $L_{\odot}^{-1}$. If the star formation rate is decreasing with time the stellar death rate, $\dot{S}$, will be even closer to $\dot{S}_b$ than $\dot{S}_c$. Similar results are obtained for other values of α.

From the previous discussion it follows that to a very good approximation $\dot{S}_b(t_1)$ corresponds to the stellar death rate per unit luminosity for systems with a constant rate of star formation and for systems with a decreasing rate of star formation.

The computations by Renzini and Buzzoni (1986) apply to elliptical galaxies dominated by a very old stellar population and with $t_1 \sim 10^{10}$ years to determine the $\dot{S}$ values. For spiral and irregular galaxies, models with continuous star formation have to the considered. To compare spiral and irregular galaxies with the models by Renzini and Buzzoni an aver age age for the stellar content has to be estimated. In spiral and irregular galaxies the stellar death rate and the total luminosity are dominated by the younger generations of stars, and an average age, weighted by the higher luminosity of the younger generations, of about $1 - 2 \times 10^9$ years, should be used. Moreover $1 - 2 \times 10^9$ years is the time that a star with $M_i \sim 1.5\ M_{\odot}$ spends in the main sequence and corresponds to the $\langle M_i \rangle$ derived from the height of PN above the galactic plane (Osterbrock 1973). An age of 1.5×10^9 years would reduce $\dot{S}$ to $\sim 18 \times 10^{-12}$ yr^{-1} $L_{\odot}^{-1}$ (see Figure 3).

For the LMC, the SMC, M81, M31 and th Galaxy the ξ values are very similar to the $\dot{S}$ value derived from the models by Renzini and Buzzor (1986), considering all the uncertainties that ente into both types of determinations. In particular, fo the Galaxy $\xi \sim (2/3)\dot{S}$; this result implies that th majority of the intermediate mass stars undergo th PN phase.

For all the galaxies in Table 2 a value of $\dot{S}$ i the range of $15 \leq 10^{-12}$ yr^{-1} $L_{\odot}^{-1} \leq 20$ can b expected; slightly higher $\dot{S}$ values for the mor luminous galaxies are expected, due to their olde stellar population (see Figure 3). Therefore th decrease of ξ with $(B-V)_0$ and with M_{bol} is not du to a decrease in $\dot{S}$ and should be explored further

Most of the PN luminosity functions, PNLF, use for the determinations of ξ in Table 2 are complet only at the high luminosity end; the completenes limit of the observations extends only $\sim$ 2.5, 1.5 1.1 and 0.8 mag below the bright end cutoff fo M31, M81, the Leo I Group (NGC 3377, NGC 337 and NGC 3384) and the Virgo Cluster (NGC 447 NGC 4686, NGC 4649, NGC 4406, NGC 437 NGC 4382) respectively. The shape of the entir PNLF is obtained by scaling the observed upper en with the PNLF for the Magellanic Clouds derive by Jacoby (1980). Since the PNLF spans about magnitudes (Ciardullo *et al.* 1989b), the ξ value represent the upper end of the PNLF. Therefore strictly speaking, it can only be said that the numbe of bright PN decreases with increasing luminosity c the galaxy.

There are at least three possible causes for th decrease in the number of bright PN with th increase of $(B-V)_0$ and luminosity: a) an increase c the heavy element abundances, b) a decrease of th average mass of the central stars of PN, $\langle M_c \rangle$, du to an age effect, and c) a decrease of the fraction c intermediate mass stars that produce luminous PN In what follows we will analyze these possibilities.

There is a well known positive correlatio between the total mass of the galaxy and th heavy element abundances that includes irregula spiral and elliptical galaxies e.g,. Lequeux *al.* 1979; Mould 1984; Garnett and Shielc 1987). From the relatively close relationshi between mass and luminosity, a positive correlatio between luminosity and heavy element abundance is also expected. Even if a higher heavy elemer abundance produces a decrease of the [O II luminosity, the expected effect is very small (Jacob 1989) and cannot explain the correlation present i Figures 1 and 2.

It is also possible that the $\langle M_c \rangle$ decreases wi the luminosity of the galaxy and consequent the luminosities of all PN. This possibility seen likely because the three galaxies of the Leo Group, at practically the same distance, have ferent $\dot{\xi}$ and the six galaxies of the Virgo Cluster, at practically the same distance, have different alues.

The third possibility is that there are two stellar pulations in each galaxy: a relatively young one, h an average age of $\sim 1 - 2 \times 10^9$ years, and old one, with an average age of $\sim 10^{10}$ years. e observed bright end of the PNLF would be due the younger population with $\langle M_c \rangle \sim 0.61$ M$_\odot$, ile the older population would seldom produce or would produce PN with $\langle M_c \rangle \leq 0.57$ M$_\odot$ ich are considerably fainter (e.g., Jacoby 1989). e brighter the galaxy, the more important the old pulation relative to the young population. The ler population is expected to produce fainter and ver PN per star due to the following reasons: a) ver luminosity of the central star, b) smaller mass the shell and c) longer stellar evolutionary times it might prevent the star to become hot enough ionize the nebula before it has dissipated.

IV. GALACTIC BIRTH RATES AND THE PN DISTANCE SCALE

From the local PN birth rate per unit volume, it is possible to determine N_T and to compare it h the N_T value derived from $\dot{\xi}$ to see if they are ncordant; $\dot{\rho}$ is given by

$$\dot{\rho} = \rho/\Delta t = \rho\langle v \rangle/(R_f - R_i), \quad (4)$$

ere ρ is the density, in the solar vicinity, of PN h $R_i < R < R_f$, Δt is the time needed for R increase from R_i to R_f, and $\langle v \rangle$ is the average ocity of expansion from R_i to R_f. Usually ρ is en in pc^{-3} and Δt in years. In the optically ck phase $\langle v \rangle$ denotes the average velocity of the ization front relative to the central star, v_{ion}; ile in the optically thin phase $\langle v \rangle$ denotes the erage velocity of expansion of matter, v_{exp}, given the Doppler effect.

There are several sources of error associated with e use of equation (4) (e.g., Phillips 1989; Peimbert 90). The main uncertainty is due to the adopted I distance scale since $\dot{\rho}$ is proportional to d^{-4}. o other sources of error are given by the adopted locity of expansion and by the assumption that st PN are optically thin. While most investigators ve used $\langle v_{exp} \rangle = 20$ km s^{-1}, a careful study by illips yields $\langle v_{exp} \rangle = 26$ km s^{-1} for objects with 0.1 R(pc) $\leq$ 0.6 and 25 km s^{-1} for objects with R $\leq$ 0.6 pc; this result increases most birth rate estimates. If a fraction of optically thick (ionization bounded) PN is assumed to be optically thin (density bounded) an error is introduced because $\langle v_{ion} \rangle$ should be used instead of $\langle v_{exp} \rangle$; this effect also increases the birth rate estimates.

One of the main problems in the study of PN is the determination of their distances. Since only a small fraction of solar vicinity PN have distance determinations based on individual characteristics, the so called direct distance determinations, it has been the aim of many investigators to find a good distance scale that can be applied to all PN (see Peimbert 1990 for a review).

To compare different distance scales it is possible to introduce a relative scale factor, k, with the normalization $k = 1$ for Seaton's (1968) distance scale. In Table 3 (taken from Peimbert 1990) we present the relative sizes for some of the most frequently used distance scales. For optically thin PN samples, $k \propto$ M(rms)$^{2/5}$, where M(rms) is the envelope mass derived from the root mean square density. For optically thick PN samples k increases with R and an average value for 0.1 $\leq$ R(pc) $\leq$ 0.3 is presented in Table 3. If objects smaller than 0.1 pc are considered the spread in k values is even larger (see Gathier 1987). In this comparison the M(rms) values have been computed under the assumptions that N(He)/N(H) = 0.11 and N(He$^+$)/N(H$^+$) + 2N(He^{++})/N(H$^+$) = 0.13.

In Table 4 we present determinations of $\dot{\rho}$, that varies as k^{-4}, and of N_T. N_T has been obtained by multiplying the galactic PN birth rate, $\dot{N}$, by the mean lifetime of PN; while $\dot{N}$ has been obtained by scaling the surface density birth rate of the solar vicinity to the overall galaxy. By this procedure N_T is proportional to k^{-2}. The N_T value from Daub's

TABLE 3

COMPARISON OF DISTANCE SCALES FOR PN WITH 0.10 $\leq$ R (pc) $\leq$ 0.30

$k = d/d_{Seaton}$	M(rms) (M$_\odot$)	Scale
1.55	...	Mallik and Peimbert (1988)
1.47	0.42	Cudworth (1974)
1.40	0.37	Schneider and Terzian (1983)
1.30	0.31	Weidemann (1977)
1.16	...	Maciel and Pottasch (1980)
1.00	0.16	Seaton (1968)
1.00	0.16	Cahn and Kaler (1971)
1.00	0.16	Milne and Aller (1975)
1.00	0.16	Acker (1978)
1.00	...	Gathier (1987)
0.95	0.14	Daub (1982)

TABLE 4

WD AND PN BIRTH RATES, AND THE TOTAL NUMBER OF PN IN THE GALAXY

$\dot{\rho}(WD)$ $(10^{-12}$ pc^{-3} yr$^{-1})$	$\dot{\rho}(PN)$ $(10^{-12}$ pc^{-3} yr$^{-1})$	$N_T(PN)$ (10^3)	k	References[a]
0.62 ± 0.13	...	...	...	1
0.72 ± 0.25	...	...	...	2
...	1.13 ± 0.3	17.9	1.47	3,4
...	2.2 ± 0.4	...	1.30	5
...	2.39 ± 0.32	29.6 ± 4.0	...	6
...	3.0	25.0	1.00	7
...	5.54 ± 1.5	40.2	1.00	3,4
...	5.0 ± 2.0	50 ± 20	0.95	4,8
...	8.0	140	...	9

a. 1) Fleming *et al.* 1986, 2) Downes 1986, 3) Alloin *et al.* 1976, 4) this work, 5) Weidemann 1977, 6) Phillips 1989, 7) Acker 1978, 8) Daub 1982, 9) Ishida and Weinberger 1987.

(1982) distance scale was obtained by assuming a mass for the Galaxy of 1.3×10^{11} $M_\odot$ (Innanen 1966) and a radius of detectability of 0.64 pc.

The N_T values derived from $\dot{\rho}$ depend strongly on k as expected (see Table 4), and all of them are higher than the N_T value derived from $\dot{\xi}$. The best agreement between both types of determinations is for Cudworth's (1974) distance scale. A better agreement is expected with the Mallik and Peimbert (1988) distance scale due to its slightly larger k value, but a detailed determination has not yet been made.

It is also possible to determine the $\dot{\xi}$ value for the solar neighborhood. Alloin *et al.* (1976) estimated the local PN birth rate for Cudworth's (1974) and Cahn and Kaler's (1971) distance scales, $\dot{\rho}$(C) and $\dot{\rho}$(CK). To determine $\dot{\xi}$ we have to correct the $\dot{\rho}$ determinations of Alloin *et al.* by the following three effects: a) the average expansion velocity of PN is 25 km s^{-1} instead of 20 km s^{-1}, b) in this paper R_m = 0.64 pc instead of 0.60 pc and c) due to the lack of southern hemisphere PN a completeness factor of 1.34 has been adopted (Cahn and Wyatt 1976). The resulting values are $\dot{\rho}$ (C) = 1.13×10^{-12} pc^{-3} yr^{-1} and $\dot{\rho}$(CK) = 5.54×10^{-12} pc^{-3} yr^{-1}. Dividing the $\dot{\rho}$ values by the stellar luminosity per unit volume for the solar neighborhood (L = 1.15×10^{-1} $L_\odot$ pc^{-3}, Allen 1973), we obtain $\dot{\xi}$(C) = 9.8×10^{-12} yr^{-1} $L_\odot$ and $\dot{\xi}$(CK) = 48.2×10^{-12} yr^{-1} $L_\odot^{-1}$. The $\dot{\xi}$(C) value is in very good agreement with the overall $\dot{\xi}$ value for the Galaxy presented in Table 2, while the $\dot{\xi}$(CK) value is considerably higher. The N_T value derived from Cudworth's distance scale (see Table 4) is larger than that derived from the overall $\dot{\xi}$ value for the Galaxy, the difference could be due a) the value of the luminosity of the Galaxy cou be larger than that adopted in Table 1, or b) t procedure based on the mass of the Galaxy to deri N_T, used by Alloin *et al.*, might be in error, may the solar neighborhood produces more PN per u mass than the Galaxy as a whole.

There are two other independent arguments tl favor long distance scales, like those of Cudwoı (1974) and Mallik and Peimbert (1988), over t other distance scales presented in Table 3: a) the determinations by Renzini and Buzzoni (1986), tl imply a maximum value of 12 600 PN for $\dot{S}_b$ = 21 10^{-12} yr^{-1} $L_\odot^{-1}$ and b) the $\dot{\rho}$(WD) values by Flemi *et al.* (1986) and Downes (1986) that are similar the $\dot{\rho}$(PN) value derived by Alloin *et al.* (1976) bas on Cudworth's (1974) distance scale (see Table 4

V. CONCLUSIONS

From the work by Jacoby and collaborators on galaxies it is found that there is a strong correlati between M_{bol} and $\dot{\xi}$, the birth rate of PN per u luminosity, in the sense that the brighter the gala the smaller the $\dot{\xi}$ value. From the same sample i also found that there is a strong correlation betwe $(B-V)_0$ and $\dot{\xi}$ in the sense that the redder the gala the smaller the $\dot{\xi}$ value.

The expected stellar death rate per unit luı nosity, $\dot{S}$, is about the same for the 15 galax considered, therefore the M_{bol} versus $\dot{\xi}$ correlati seems to imply that the fraction of stars that through the PN stage decreases with the lumiı sity of the galaxy, and with the average age of t stellar population. Since only the brighter end of the PN luminosity function is used to determine $\dot{\xi}$, it can only be concluded that the number of bright PN decreases with increasing M_{bol} and with $(B-V)_0$. To explain these correlations several possibilities are discussed and it is suggested that there are two stellar populations in each galaxy: a relatively young one, with an average age of $\sim 1-2\times 10^9$ years, and an old one, with an average age of $\sim 10^{10}$ years. The observed bright end of the PNLF would be due to the younger population with $\langle M_c\rangle \sim 0.61\ M_\odot$, while the older population would seldom produce PN or would produce PN with $\langle M_c\rangle \leq 0.57\ M_\odot$ which are considerably fainter. The brighter the galaxy the more important the old population relative to the young one.

From a comparison of $\dot{S}$ and $\dot{\xi}$ for galaxies with fainter luminosities than $M_{bol} = -22.0$ it is found that a large fraction of the stars in the $0.8 \leq M_i\ (M_\odot) \leq 8$ range go through the PN stage.

From the M_{bol} versus $\dot{\xi}$ and the $(B-V)_0$ versus $\dot{\xi}$ relationships it is estimated that $\dot{\xi} = (12 \pm 3) \times 10^{-12}\ \mathrm{yr}^{-1}\ L_\odot^{-1}$ for the Galaxy. This value implies that the total number of PN, N_T, is equal to 7200 ± 1800 PN. From the Cudworth (1974) distance scale it is found that $\dot{\xi}(C) = 9.8 \times 10^{-12}\ \mathrm{yr}^{-1}\ L_\odot^{-1}$ in very good agreement with the overall $\dot{\xi}$ value for the Galaxy. From the Cahn and Kaler (1971) distance scale and the local birth rate it is found that $\dot{\xi}(CK) = 48.2 \times 10^{-12}\ \mathrm{yr}^{-1}\ L_\odot^{-1}$ in disagreement with the overall $\dot{\xi}$ value for the Galaxy.

From the computations by Renzini and Buzzoni (1986) it is found that for the Galaxy, $\dot{S} \leq 21 \times 10^{-12}\ \mathrm{yr}^{-1}\ L_\odot^{-1}$ which means that $N_T \leq 12\,600$ PN.

By comparing the N_T value derived from the $\dot{\xi}$ value with the N_T values derived from the local PN birth rate per unit volume, $\dot{\rho}$(PN), it is found that long distance scales like those by Mallik and Peimbert (1988) and by Cudworth (1974) are favored over shorter ones. The $\dot{S}$ values by Renzini and Buzzoni (1986) and the $\dot{\rho}$ (WD) values by Downes (1986) and Fleming *et al.* (1986) also favor the long distance scales.

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