THE MASSES OF THE IONIZED GAS OF PLANETARY NEBULAE ENVELOPES IN LARGE MAGELLANIC CLOUD

V.Holovatyy [1], A.Demchyna [2]

Ivan Franko National University of Lviv, Lviv, Ukraine
[1] vholovatyy@gmail.com, [2] ademchyna@gmail.com

ABSTRACT. The masses of ionized gas in the shells of planetary nebulae which belong in the Large Magellanic Cloud are calculated by three different ways. The value of mass is calculated for the cases: 1) spherical, 2) elliptical forms of envelopes and 3) commonly known method based on the line ratio F(H_β) of the shell to its emissivity of ε(H_β). It is shown that the values of masses M_i of nebulae envelopes differ up to 50%. The values of M_i calculated by the other methods which differ more from previous ones. We consider the dependence of M_i on the radius and the electron density in the envelopes of nebulae.

Key words: mass of ionized gas, planetary nebulae of LMC

To determine the masses of ionized gas in the shells of planetary nebulae (PN) are commonly used method based on the observed radiation flux F(H_β)from its envelopes in line H_β and its emissivity ε(H_β) [2]. As a result the volume of gas emitted V(H^+)= 4πr^3·F(H_β)/ε(H_β)is determined by a sphere of radius r and respectively of the ionized hydrogen mass M_i with the helium atoms :

$$M_i(\mathrm{r})=(\frac{4}{3}\pi r^3)\cdot \varepsilon \cdot n(H^+)\cdot m_H\cdot(1+4y),$$

where r is radius envelopes PN (distance to PN 50,6 kpc [6]), $n(H^+)$is concentration of H ions. Factor (1+4y) takes into account the contribution of the atoms He. The filling factor $\varepsilon = 1$, if the sphere is completely filled of uniform density gas, and $\varepsilon < 1$, if it is only partially filled.

It is known that the masses of envelopes PN founded of different authors are differ vary. One explanation for this difference is that forms of envelopes PN different from spherical, i.e. are elliptical. The values ofcorresponding sides of the ellipses are given in [6].

In this paper is investigated the influence of different radiuses of the ellipses, on the determination V and, corresponding, mass M_i of the envelopes PN.

The values of the corresponding parameters for determining M_i are derived in table. Col.1 contains the name of PN, col.2 and col. 3 gives the values of parties ellipses [6] col. 4 contains fluxes in line F(H_β) [5], col.5 contains the electron temperatures, col.6 contains the electron density n_e [5]. Some data of the electron density n_e were taken from [1,3,4]. To calculate the volumes of envelopes PN used the formula V(r) = $\frac{4}{3}\pi r^3$ are derived (col.7). In col. 8 are derived V(r = a) = $\frac{4}{3}\pi a^3$. Col. 9 contain V(a,b) = $\frac{4}{3}\pi (a\cdot b)^2$ and presents the volumes founded into account the shape of envelope, corresponding. These dates of the volumes of envelopes PN and the electron densities n_e, were used for calculation of the ionized gas masses:

$$M_i = \mathrm{V}\cdot n(H^+)\cdot m_H\cdot(1+4y),$$

The corresponding values of the mass of ionized gas in the envelopes PN are gives in col.10, 11, 12 table, corresponding.

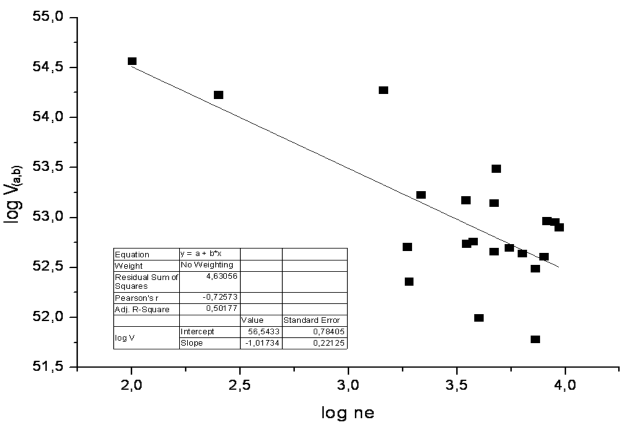

Figure 1. Dependence of the electron density from the volumes of the envelopes PN

Table : Parameters of envelopes PN

NAME PN	diameter		$F(H_\beta)$	Te	n_e	V(r)	V(r=a)	V(a,b)	M_i (r)	M_i (r=a)	M_i (a,b)
	a	b									
	arcsec	arcsec	$erg/cm^2 s$	K	cm^{-3}	cm^3	cm^3	cm^3	$M_\odot$	$M_\odot$	$M_\odot$
1	2	3	4	5	6	7	8	9	10	11	12
SMP3	0,26	0,23	-12,19	13800	7244	5,80E+52	7,81E+51	6,10E+51	0,35	0,04	0,05
SMP5	0,46	0,5	-12,02	11700	1862	9,30E+53	4,33E+52	5,10E+52	1,45	0,08	0,07
SMP6	0,67	0,56	-12,11	13300	8202	5,00E+52	1,34E+53	9,30E+52	0,35	0,64	0,92
SMP14	2,41	1,87	-13,25	10090	100 [4]	1,40E+55	6,22E+54	3,70E+54	1,18	0,32	0,52
SMP29	0,51	0,47	-12,63	20000	5495	7,60E+52	5,89E+52	5,00E+52	0,35	0,23	0,27
SMP37	0,5	0,43	-12,52	13600	7943	2,20E+52	5,55E+52	4,10E+52	0,15	0,27	0,37
SMP45	1,66	1,62	-12,73	15900	1445	5,50E+53	2,03E+54	1,90E+54	0,67	2,35	2,47
SMP48	0,4	0,36	-12,33	13200	1900 [1]	5,50E+53	2,84E+52	2,30E+52	0,88	0,04	0,05
SMP52	0,73	0,73	-12,24	12300	2153	4,60E+53	1,73E+53	1,70E+53	0,84	0,31	0,31
SMP62	0,59	0,41	-12,1	15700	6310	1,20E+53	9,13E+52	4,40E+52	0,64	0,23	0,48
SMP63	0,63	0,57	-12,25	11200	8913	2,20E+52	1,11E+53	9,10E+52	0,16	0,68	0,83
SMP67	0,88	0,61	-12,66	12400	3467	6,90E+52	3,03E+53	1,50E+53	0,20	0,42	0,88
SMP69	1,84	1,43	-13,17	-	250 [4]	-	2,77E+54	1,70E+54	-	0,35	0,58
SMP73	0,31	0,27	-12,16	13100	3981	1,80E+53	1,32E+52	1,00E+52	0,61	0,03	0,04
SMP74	0,79	0,63	-12,11	12500	4677	1,40E+53	2,19E+53	1,40E+53	0,54	0,55	0,86
SMP84	0,57	0,48	-12,63	13300	3750 [3]	7,20E+52	8,23E+52	5,80E+52	0,23	0,18	0,26
SMP88	0,61	0,45	-12,49	25500	3500 [4]	4,20E+53	1,01E+53	5,50E+52	1,23	0,16	0,30
SMP89	0,51	0,45	-11,94	12300	4677	2,00E+53	5,89E+52	4,60E+52	0,77	0,18	0,23
SMP92	0,62	0,54	-12,07	13400	9333	4,30E+52	1,06E+53	8,00E+52	0,34	0,63	0,83
SMP98	0,41	0,41		12800	7244	-	3,06E+52	3,10E+52	-	0,19	0,19
SMP101	1,03	0,82	-12,7	15200	4786	4,90E+52	4,86E+53	3,10E+53	0,20	1,24	1,95

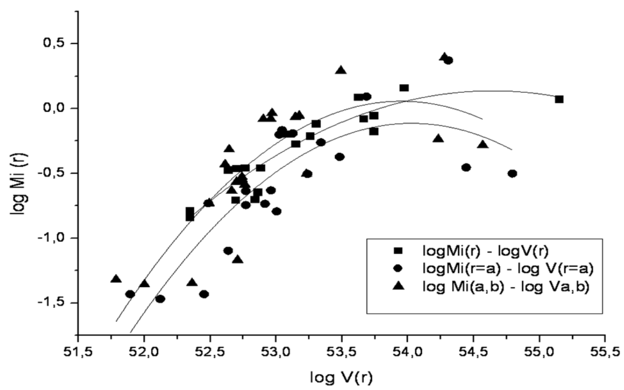

Figure 2. Dependence of the masses of ionized gas M_i from the volume of the envelopes PN V

Figure 1 shows the dependence of the electron concentration n_e from the volumes of the envelopes PN. It is clearly seen when the volume of envelopes PN are increased then electron density n_e are decreased. An approximation of this dependence logV(a,b)=1,017log n_e+56,54.

Figure 2 shows the dependence of the masses of ionized gas in the envelopes M_i from its V. It is clearly seen that the difference between acceptable forms of envelopes PN lead to a large difference in values M_i comparable to the variation of the masses found by different authors.

References

1. García-Hernández D. et al.: 2012, *ApJ*, **760,** 107.
2. Holovatyy V., Demchyna A.: 2013, *JPhSt*, **17**, 1, 1902.
3. Holovatyy V., Melekh B.: 2012, *Astron J.*, **90**, 5, 406.
4. Leisy P., Dennefeld M.: 1996, *Astron. Astrophys*., **116**, 95.
5. Richer M.: 1993, *ApJ*, **415**, 240.
6. Villaver E., Stanghellini L.: 2007, *Astron. J.*, **656**, 831.