THE DYNAMIC EVOLUTION OF THE SHELL NEBULAE BY USING INTERACTING WIND MODEL

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1-Introduction

Planetary Nebulae (PN) are astronomical objects made up primarily of gaseous materials. A planetary nebulae are an emission nebulae consisting of an expanding glowing shell of ionized gas ejected during the Asymptotic Giant Branch (AGB) phase. of certain types of stars late in their life. late in their life,[1]. This name originated with their first discovery in the 18th because of their similarity in appearance to giant planets when viewed through small optical telescopes, and is otherwise unrelated to the planets of the solar system,[2]. The importance of winds from central stars of PN in preventing material backfill was recognized as early as 1966 by Mathews (1966),[3]. The resents IUE observations have shown that winds from central stars are much more common than previously thought. Heap (1982) was the first suggested that central stars with a luminosity to mass ratio >11,000 will have wind. Combining this empirical criterion with the Pycznski core mass-luminosity relationship, we have lower central star mass limit of ~0.65Mo,[4].The wind velocities can be accurately measured and have been found to range from 2000-8000 km/s. central stars with higher temperatures are also suspected to generate higher velocity winds. It is easy to show that such high velocity winds carry a significant amounts of momentum and energy and should have an important effect on the dynamical evolution of PN. Fig (1) shows the formation phases of planetary nebulae on HR Diagram.

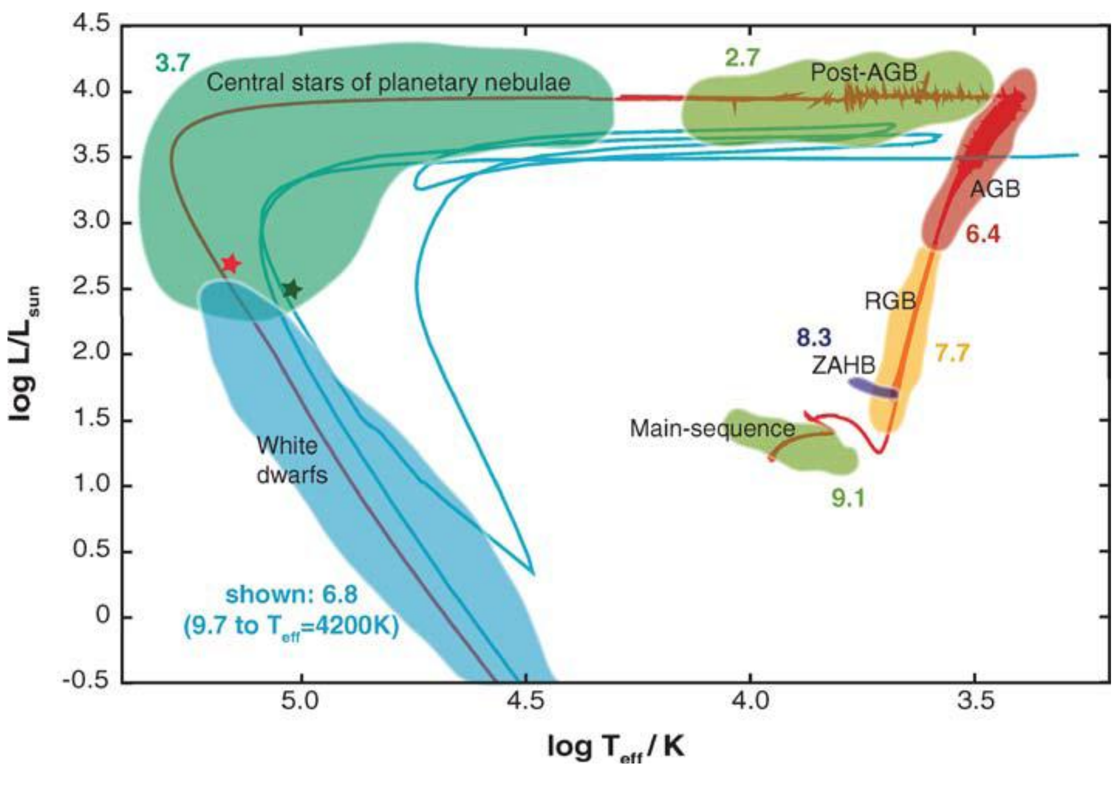

Fig (1) represents the formation of planetary nebulae from Red Giant to the white dwarf phase,[5]].

2-The Origin of PN

After the Asymptotic Giant Branch (AGB) phase, the short planetary nebula phase of stellar evolution begins as gases drift away from the central star at speeds of a few kilometers per second,[2]. The central star is the remnant of its AGB progenitor, an electron-degenerate carbon-oxygen core that has lost most of its hydrogen envelope due to mass loss on the AGB as shown in fig (2),[1]. As the gases expand, the central star undergoes a two stage evolution, first growing hotter as it continues to contract and hydrogen fusion reactions occur in the shell around the core and then slowly cooling once the hydrogen shell is exhausted through fusion and mass loss,[5]. In the second phase, it radiates away its energy In the second phase, it radiates away its energy and fusion reactions cease, as the central star is not heavy enough to generate the core temperatures required for carbon and oxygen to fuse,[6]. Fig (2) shows the processes which occurs for the AGB star core,[7&8].

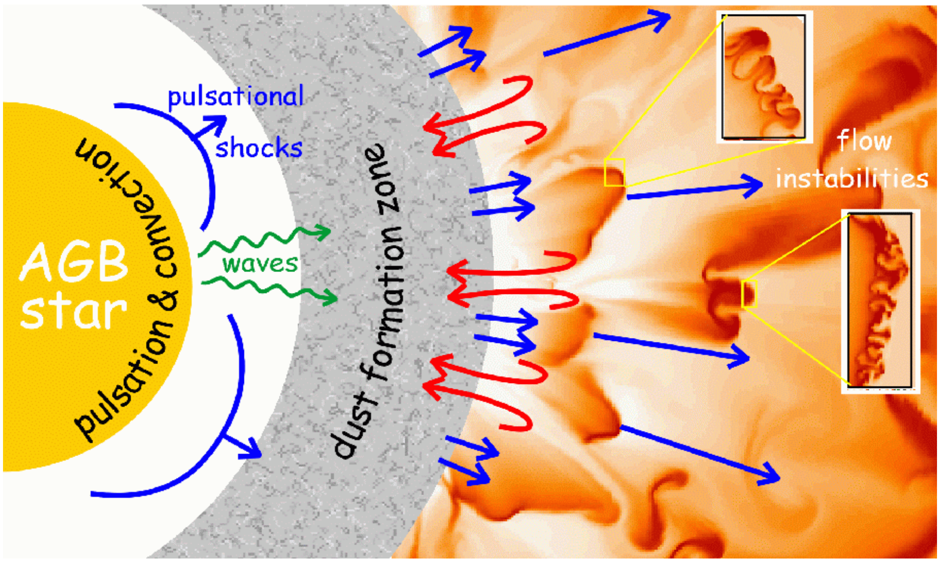

Fig. (2) the processes which flows as core star formation,[8].

2- Interaction Stellar Model

The important of red-giant mass loss in the formation of PN is obviously dependent the transition time from red giant to PN,[5]. For stars with core masses between 0.6 and 1.2 Mo, Pycznski 1971 it can be shown that the transition is relatively rapid, particularly for high mass stars. Renizi 1981, Marigo 2003 &Kwok 2005 have also convincingly argued that this transition time cannot be longer than the expansion time of PN (~10^4yr) otherwise the nebulae will not be ionized before it disperses into the interstellar medium,[6]. Given the short transition time scale, the extensive circumstellar envelope created by steady mass loss during the AGB should not be of neglected in the treatment of the formation process of PN, regardless of the ejection mechanism,[7].

3- The Model Prescriptions

A suddenly ejected PN shell can easily sweep up a fraction of solar mass of wind material over the life time of PN and what we observe as PN in fact consist mainly of wind material left over from the AGB phase ,[1]. This possibility has been Evaluated by Kwok who explore the extreme case where there is no sudden ejection and the steady red-giant wind can persistently the exposure of the hot core. In this research the results of interacting wind (synthetic model) comparing with the results of previous Sun Kwok (SK)model by using adopted values for these models. UV photons from the core will exert pressure via resonance lines on the gas and a new fast wind initiated. This new wind will soon interact with the remnant of the central star envelope and like snow plow, creates a dense shell at the interface of the two winds. Assuming that PN is made up exclusively of wind material then the mass of. in fact,

$$Ms = (\frac{\overset{*}{M}}{V} - \frac{\overset{*}{m}}{v})Rs(t) - (\overset{*}{M} - \overset{*}{m})t \quad \text{------------- (1)}$$

, (V& v) $\overset{*}{M} \& \overset{*}{m}$ Where:

are the mass loss rates (velocities) of the red-giant and PN central star winds respectively. when the transition time (τ)is taken into account, Ms is given by:

$$Ms(t) = (\frac{\overset{*}{M}}{V} - \frac{\overset{*}{m}}{v})Rs(t) - \overset{*}{M}\,t + \overset{*}{m}(t - \frac{V\tau}{v-V}) \quad \text{--------------- (2)}$$

Where t=0 is when the red giant wind stops and t= τ =t_{tr} is the time when the central star wind begins. In approximation that collision of the two winds is totally inelastic and all the excess energy is radiated away ,Rs quickly approaches an equilibrium velocity :

$$Vs = \frac{(\overset{*}{M} - \overset{*}{m}) + (v - V)(\overset{*}{M}\,\overset{*}{m}/\,vV)^{0.5}}{(\overset{*}{M}/V - \overset{*}{m}/\,v)} \quad \text{--------------------------------- (3)}$$

since the central star wind carries significant amount of mechanical energy ,it is not all of its energy cancan be radiated away, ,especially during the later stages of PN expansion when the density is low. At high temperature zone may develop due to shock heating and thermal gas pressure (p) may become an important term in the force equation. Assuming no radiative losses ,we have,[6] :

$$\frac{d}{dt}[Ms(t)\frac{dRs(t)}{dt}] = \overset{*}{m}(v - \frac{dRs}{dt}) + \overset{*}{M}(\frac{dRs}{dt} - V) + 4\pi Rs^2(t)\,p(t) \quad \text{---------------- (4)}$$

The internal energy of the hot region can be written as:

E (t)=3/2 (4/3πRs^3)p (t) ------------------- (5)

And the energy balance s of hot region is :

$$\frac{dE(t)}{dt} = \frac{1}{2}\overset{*}{m}v^2 - 4\pi Rs^{\,2}(t)\,p(t)\frac{dRs}{dt} \quad \text{------------------------ (6)}$$

Substituting (1)into (4),we can obtain similarity solution s to (4), (5), (6):

E=at

Rs=Vs*t ------------- (7)

P=c t^{-2}

Vs is the root of the cubic equation :

$$(\frac{\overset{*}{M}}{V} - \frac{\overset{*}{m}}{v})Vs^3 - 2(\overset{*}{M} - \overset{*}{m})Vs^2 + (\overset{*}{M}\,V - \overset{*}{m}\,v)Vs - \frac{\overset{*}{m}\,v^2}{3} = 0 \quad \text{---------------------- (8)}$$

$$c = \frac{1/2\,\overset{*}{m}\,v\text{^}2}{6\pi Vs\text{^}3} \quad \text{-------------------------- (9)}$$

$$\text{-----------------} \quad a = 2\pi Vs^3 c \quad \text{--------------- (10)}$$

Figures (3& 4) show shell velocity as a function of mass loss for the momentum and energy conservation cases for our model (Synthetic) when transition time is 7000 year for Mc=0.66Mo with Sun Kwok model when transition time about 3000 year for the same core mass (Mc) as shown in Fig. (3) and Fig. (4). The derived expansion velocities are comparable to observed values. Robison ,Reay and Athertoen ,Marigo (2004) have found evidence for increasing values of V_s with $R_{s.}$ This could be the result of increasing strengths of the central star wind or the result of a change from momentum –to energy – conserving approximations. If we accept the result that dRs/dt = constant, (2)can be written as :

$$Ms = \overset{*}{M}\left(\frac{1}{V} - \frac{1}{Vs}\right)Rs - \overset{*}{M}\,\tau \quad \text{---------------} \ (11)$$

This can be compared with the empirical Ms-Rs relationship found by Masiel and Pottasch (1980),[pottach]. The mass shell of Planetary Nebulae (PN) increase linearly with time and with mass loss in fast wind phase as shown in Fig. (6) for Synthetic model (Syth10) in a good agreement with the results of Sun Kwok model which indicated in Fig. (5).

$$Ms(Mo) = 1.225Rs(pc) - 0.0123 \quad \text{---------} \ (12)$$

Comparison of (11) and (12) shows that Mτ ~0.0123 Mo and

$$\overset{*}{M}\left(\frac{1}{V} - \frac{1}{Vs}\right) = 1.2 \times 10^{-6} \ (Mo/yr)/kms^{-1}$$

$$\overset{*}{M} = 2 \times 10^{-5} Mo/yr \ \text{: Where}$$

M*=2 $\times 10^{-5}$Mo/yr,V=10km/s,Vs=25 km/s for τ =600yr. although the consistency of (12) with the interacting winds model may be coincidental, it remain that the existence of such an Ms-Rs relation is difficult to understand in the conventional. the size of shell increase with the transition time as shown in Fig. (7) , that is due to the fact that the stars with low core mass leave the AGB phase with large envelope (H envelope) while the stars with high core mass leave the AGB phase with small H envelope, according to our model (Synthetic model) the stars with masses (0.89-7 Mo) have transition time about (7400-3000 yr) as we found in previous calculations.

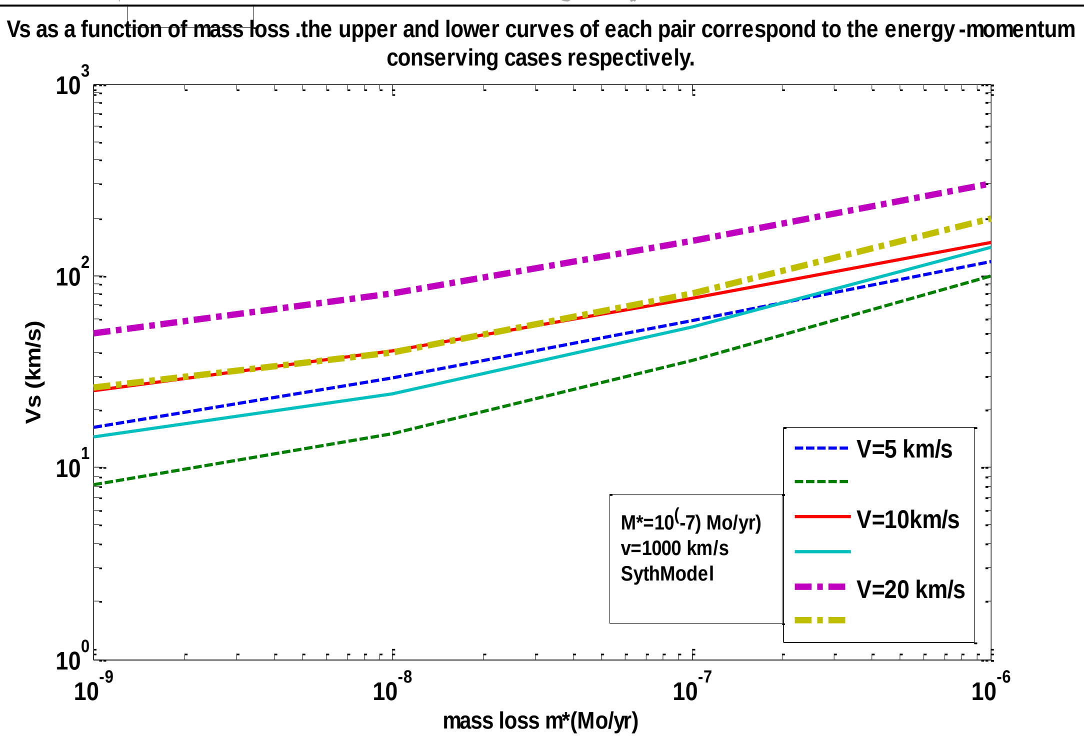

Fig. (3). Velocity of shell as a function of mass loss according to energy-momentum conservation cases for Synthetic model (Syth10) model.

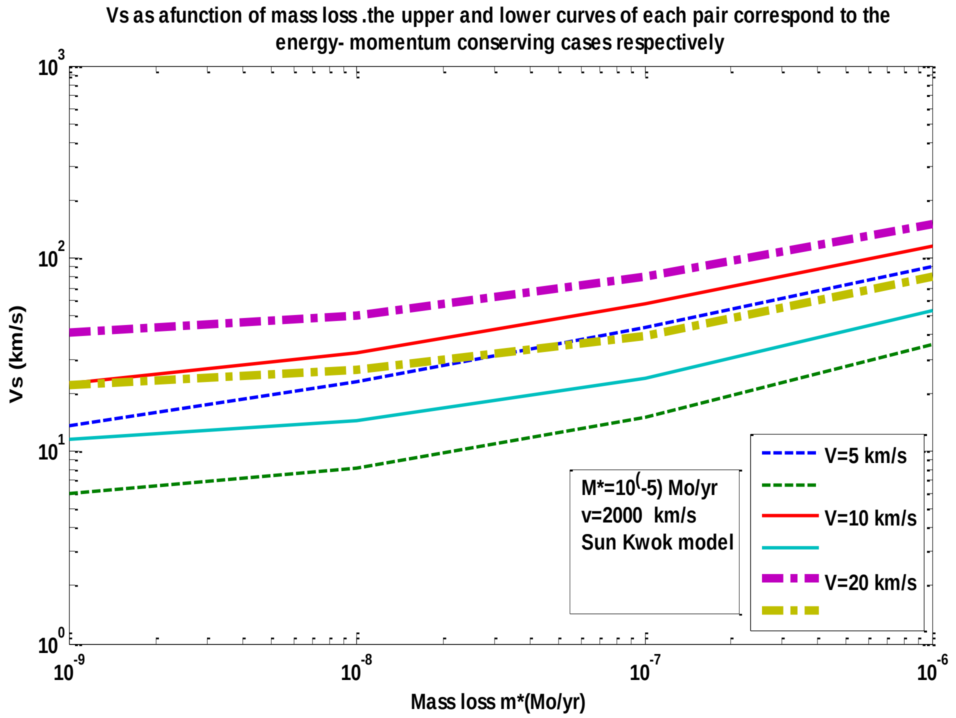

Fig. (4). Velocity of shell as a function of mass loss according to energy- momentum conservation cases for Sun Kwok model (SK08).

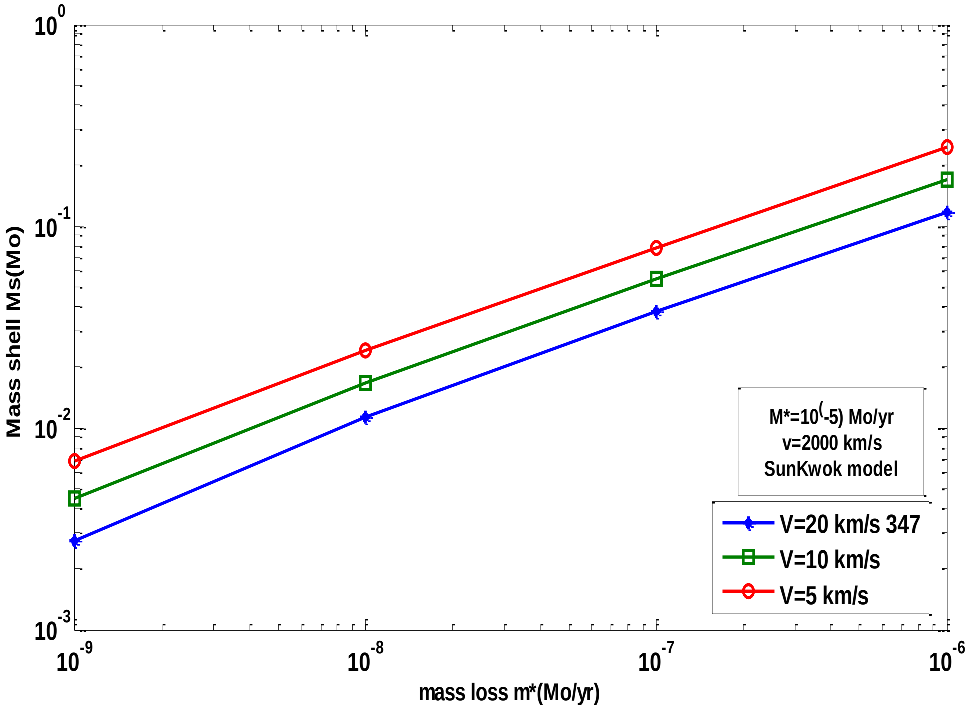

Fig. (5). The relation between mass shell as a function of mass loss according to Sun Kwok model.

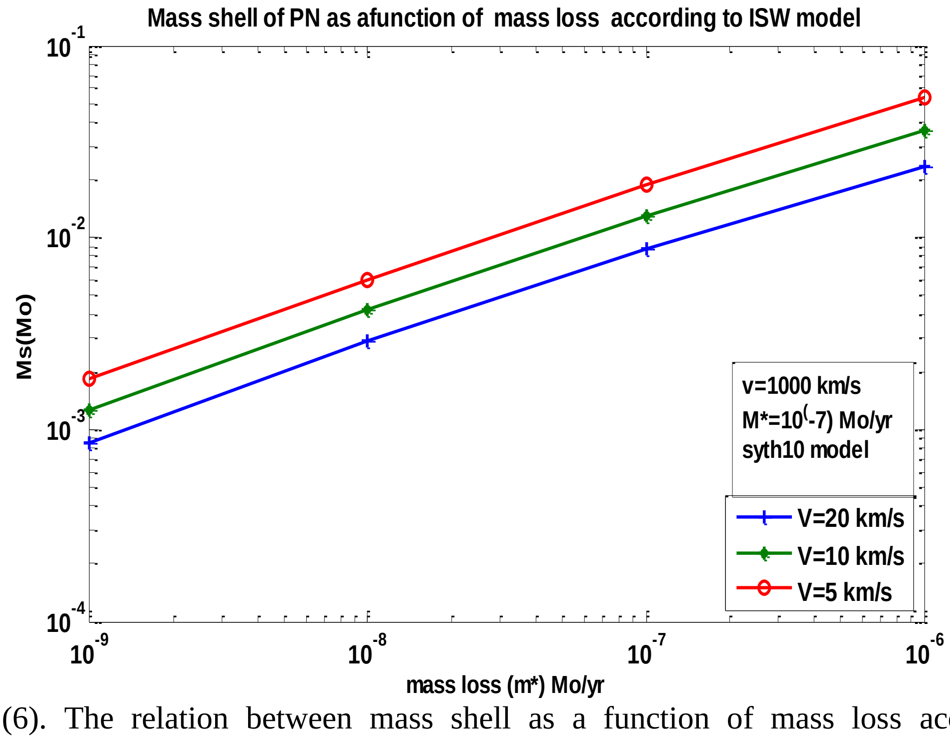

Fig. (6). The relation between mass shell as a function of mass loss according to Synthetic (Syth10) model.

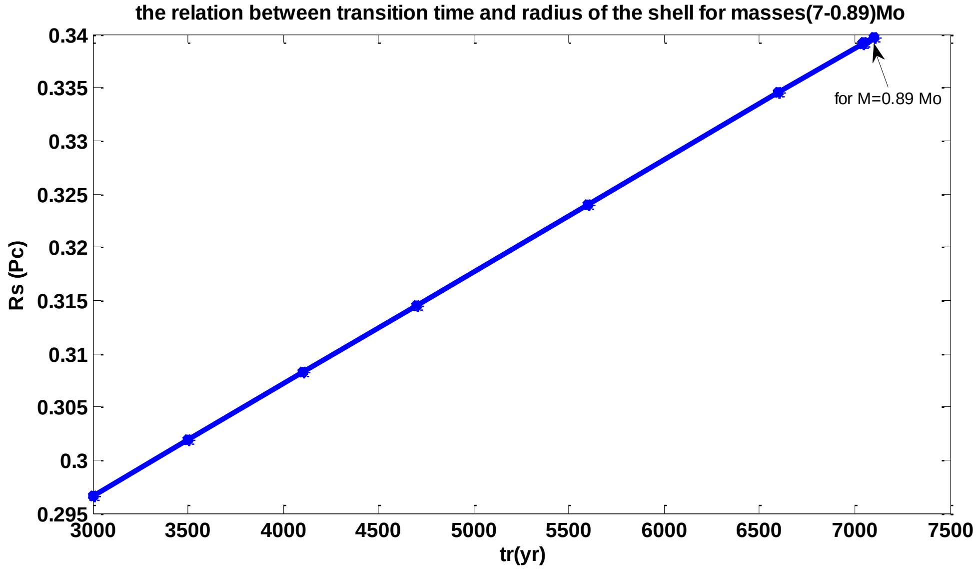

Fig (7).The radius of the shell of PN as a function of transition times for different masses

Conclusions:

1- The results showed that the increasing of Vs as a result of increasing strengths of the central star wind or the result of change from momentum –to energy –conservations approximations.

2- Mass shell have smaller values according to the Synthetic model than Sun Kwok that is due to the mass loss during Red Giant Branch (RGB)about (10^{-7})Mo/yr while-10^{-5} Mo/yr) for Sun Kwok model.

3- The results indicated that the AGB evolution is terminated not by a sudden ejection but by a steady wind over a period of $\geq 10^4$ yr.

4- The interacting winds processes will remain a basic component of the PN phenomenon.

5- The size and mass of the shell of PN increase linear with the time .

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