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A4_16 How Long will the Milky Way Last?

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Abstract

This article investigates how long the Milky Way can sustain the current star formation rate. It is assumed in this paper that no appreciable mass is added, and neglects star death. It is found using a simplified model that the Milky Way can continue with its current estimated star formation rate of 7.5 stars per year for another 9.1 x 10^9 years.

Introduction

Without appreciable accretion of new material the Milky Way will have a finite lifetime before all star formation will cease. Current estimates suggest that approximately 7.5 new stars [1] are formed every year, however only approximately 1.9 supernova events occur every century [1], it is necessary to conclude from this then that at some point in the future the star formation in the Milky Way will have to cease, as the available material in the Milky Way will be depleted. The purpose of this article is to determine how long the Milky Way can sustain its current star formation rate, with the assumption that no mass is added to the Milky Way, and neglecting star death.

Mass of the Milky Way

First we have to work out the total mass of the Milky Way galaxy and thus determine the initial amount of material available for star formation. For the sake of simplicity it will be assumed that most of the mass of the Milky Way is contained within the orbit of our Sun (which is approximately 8Kpc from the galactic centre [2]). To calculate the mass contained within this orbit, we can use Kepler's third law after initially calculating the orbital period of some test particle orbiting at this distance. We can do this by assuming that the test particle has all the same characteristics as the Sun, i.e. the same orbital speed around the galactic centre. The orbital period of the test particle is given by,

$$P = \frac{2\pi R}{\theta} \quad , \quad (1)\ [2]$$

where R= 8Kpc [2] is the radius of the galacto-centric orbit and $\theta =$ 220kms^{-1} [2] the orbital speed. This calculates the orbital period of the test particle to be 7.05 x 10^{15} s^{-1}.

Keplers third law states,

$$M = \frac{4\pi^2 R^3}{GP^2} , \quad (2)\ [2]$$

where G is the gravitational constant, 6.672 x 10^{-11} Nm^{2}kg^{-2} [3], P is the orbital period calculated in equation 1 and M the mass of the Milky Way galaxy. It is assumed that the mass of the galactic centre is much larger than the mass of the test particle orbiting it and therefore this mass can be neglected. The mass of the Milky Way can then be found to be 1.79x10^{41} kg, or in solar masses 9.00x$10^{10}$$M_{Sun}$. One of the most current estimated values of the mass of the Milky Way has been found to be 6.43 ± 0.63 x 10^{10} M_{Sun}[4]. The discrepancies in these values are simply due to the very simplified calculation used in this paper and that this calculation neglects the mass lost from the galaxy thus making it an overestimate.

Life of the Milky Way

One of the most recent estimations of the stellar production rate is which equates to 7.5 stars per year which equates to $4M_{sun}$ of mass used per year [1]. If we divide the total mass of the Milky Way by the stellar production rate (in terms of mass) then we get the total lifetime of the galaxy, 2.25×10^{10} years. We can assume that the approximate age of the Milky-Way is equal to the age of the oldest stars in the Universe, which are estimated around 13.4 billion years old [5]. Therefore, the time the Milky Way can sustain its current star formation rate is 9.1×10^9 years. If we compare this with the mass of the Milky Way estimated in recent research [4] it can be found that star formation (at a rate of 4 M_{Sun} per year) could be sustained for approximately 1.61×10^{10} years. Once again assuming the age of the Milky Way to be 13.4 billion years [5] the estimated star formation rate could be sustained for a further 2.68×10^9 years. Once again there is a discrepancy between these two values, and this is again due to the initial assumptions made in the simplified calculation outlined in this paper. The most considerable of which is that the mass is assumed to not be lost from the Milky Way, whereas in reality this will indeed occur.

Discussion

The main assumptions that were made were that no mass was added to the Milky-Way and that once a star is formed it retains its mass. This assumption then neglects star death, and the expelling of mass from the stellar surface. A more accurate picture is then presented using recent research data into the mass of the Milky Way. However for a truly accurate picture of the estimated time the Milky way can sustain its current rate of star formation a much more complex model is necessary, i.e. that includes star death, in falling material into the Milky Way and the change in the star formation with mass and time, however this is far beyond the scope of this article.

Conclusions

It has been determined how long the Milky Way can sustain its current star formation rate using a simplified model. It was found that with no appreciable mass being added it can continue forming stars at the approximate rate of 7.5 stars per year for 9.1×10^9 years.

References

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