Expansion of the Universe

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Abstract

This article contains the germinal idea of an attempt to explain the accelerated expansion of the universe using classical concepts

Introduction

The accelerated expansion of the universe[1] appears to be an amazingly counter intuitive idea based on Dark Energy[2]. In the background of such a propensity the article endeavors to explain the accelerated expansion of the universe using classical concepts.

An expanding Two Body System

[with the creation of a third mass]

We consider two masses each m separated by a distance 'r' and apply Newton's Universal Law of Gravitation[3]]

If the distance doubles potential energy increases

Initial PE=$-G\frac{m^2}{r}$-

final PE=$-G\frac{m^2}{2r}$

Now let us consider the formation of a mass m' between the two masses when they are $2r$ distance apart.

Self energy=$-\frac{3}{5}G\frac{m\prime^2}{R}$

R:Radius of galaxy formed; r: inter galactic separation r>>R

Final PE,

$$= -G\frac{m^2}{2r} - 2G\frac{mm'}{r} - \frac{3}{5}G\frac{m'^2}{R}$$

Condition for net PE decrease

=

$$-G\frac{m^2}{r}-\left(-G\frac{m^2}{2r}-2G\frac{mm\prime}{r}-\frac{3}{5}G\frac{m\prime^2}{R}\right)>0$$

$$-G\frac{m^2}{2r}+2G\frac{mm'}{r}+\frac{3}{5}G\frac{m'^2}{R}>0$$

Decrease in PE creates mass and kinetic energy

$$-G\frac{m^2}{2r}+2G\frac{mm'}{r}+\frac{3}{5}G\frac{m'^2}{R}=m'c^2+additionalKE$$

$$\frac{3}{5}G\frac{m'^2}{R}+m'\left(2G\frac{m}{r}-c^2\right)-\left(G\frac{m^2}{2r}+KE\right)=0\ (1)$$

$$m'=\frac{\left(c^2-2G\frac{m}{r}\right)\pm\sqrt{\left(c^2-2G\frac{m}{r}\right)^2+4\frac{3}{5}G\frac{1}{R}\left(G\frac{m^2}{2r}+KE\right)}}{\frac{6}{5}G\frac{1}{R}};R\ll r\ \ (2)$$

Mass m' is positive for positive value of determinant

$$m'=\frac{\left(c^2-2G\frac{m}{r}\right)+\sqrt{\left(c^2-2G\frac{m}{r}\right)^2+4\frac{3}{5}G\frac{1}{R}\left(G\frac{m^2}{2r}+KE\right)}}{\frac{6}{5}G\frac{1}{R}}>0;c^2-2G\frac{m}{r}>0$$

The smaller the value of R the smaller will be m'. That means formation of smaller volume of mass will reduce m'.

$$m'\propto R$$

when other factors are constant

Hefty masses are not required .Approximate point mass formation [for m']like neutron star formation or black hole formation over the years is good enough.

An Expanding Many Body System

Let us consider 'n' equal masses in the fray. Let n' new masses each having mass m' be formed.
The mutual separations of the earlier configuration have changed from $r_{ij}$to $r_{ij}{}'$. The new masses have a mutual separation of R_{ij}. Their separation from the earlier masses: $R_{ij}{}'$

Initial PE

$$-\sum_{i<j} G\frac{m^2}{r_{ij}}$$

Final PE of interaction

$$-\sum_{i<j} G\frac{m^2}{r_{ij}'}-\sum_{i<j} G\frac{m'^2}{R_{ij}}-\sum_{i<j} G\frac{mm'}{R'_{ij}}$$

Self energy of each mass formed:

$$-\frac{3}{5}\sum_{j}\frac{m'^2}{R_j}$$

$$\sum_{i<j} G\frac{m^2}{r_{ij}'}+\sum_{i<j} G\frac{m'^2}{R_{ij}}+\sum_{i<j} G\frac{mm'}{R'_{ij}}+\frac{3}{5}G\sum_{j}\frac{m'^2}{R_j}-\sum_{i<j} G\frac{m^2}{r_{ij}}=n'm'c^2+(additional)KE_{total}(3)$$

=

$$nC2G\frac{m^2}{r_1{}'}+n'C2G\frac{m'^2}{r_2}+nn'G\frac{mm'}{r_3}+\frac{3}{5}Gn'\frac{m'^2}{R_4}-nC2G\frac{m^2}{r_1}=n'm'c^2+(additional)KE_{total}(4)$$

r_1, r_1', r_2, r_3 and R_4 are the harmonic means of $r_{ij}, r_{ij}{}', R_{ij}, R'_{ij}$ and R_j respectively.

$$m'^2\left(\frac{n'C2G}{r_2}+\frac{3n'G}{R_4 5}\right)+n'm'\left(G\frac{nm}{r_3}-c^2\right)+nC2Gm^2\left(\frac{1}{r_1}-\frac{1}{r_1{}'}\right)-(additional)KE_{total}=0$$

$$m' = \frac{-n'\left(G\frac{nm}{r_3}-c^2\right)+\sqrt{n'^2\left(G\frac{nm}{r_3}-c^2\right)^2-4n'\left(\frac{C2G}{r_2}+\frac{3G}{R_4 5}\right)\left[nC2Gm^2\left(\frac{1}{r_1}-\frac{1}{r_1{}'}\right)-(additional)KE_{total}\right]}}{2\left(\frac{n'C2G}{r_2}+\frac{3n'G}{R_4 5}\right)} \quad (5)$$

$\frac{1}{r_1}-\frac{1}{r_1{}'}>0$since due to an expanding system we have $r_1' > r_1$

Case I

$$G\frac{nm}{r_3}-c^2>0;\frac{n'C2G}{2r_2}\ll\frac{3n'G}{R_4 5}$$

if $\left[nC2Gm^2\left(\frac{1}{r_1}-\frac{1}{r_1{}'}\right)-KE_{total}\right]<0$the discriminant will definitely positive. A large KE_{total} will favor such an event and positive m'.

If

$$\frac{3n'G}{R_4 5}\gg\frac{n'C2G}{r_2}\Rightarrow\frac{3}{R_4 5}\gg\frac{n'}{r_2}\Rightarrow r_2\gg\frac{5}{3}n'R_4$$

then

$$m'=\frac{-n'\left(G\frac{nm}{r_3}-c^2\right)+\sqrt{n'^2\left(G\frac{nm}{r_3}-c^2\right)^2-4n'\left(\frac{C2G}{r_2}+\frac{3G}{R_4 5}\right)\left[nC2Gm^2\left(\frac{1}{r_1}-\frac{1}{r_1{}'}\right)-KE_{total}\right]}}{2n'\frac{3G}{R_4 5}}$$

$$m'=R_4\frac{-n'\left(G\frac{nm}{r_3}-c^2\right)+\sqrt{n'^2\left(G\frac{nm}{r_3}-c^2\right)^2-4n'\left(\frac{C2G}{r_2}+\frac{3G}{R_4 5}\right)\left[nC2Gm^2\left(\frac{1}{r_1}-\frac{1}{r_1{}'}\right)-KE_{total}\right]}}{2n'\frac{3G}{5}}\quad(6)$$

$$m'=R_4\frac{-\left(G\frac{nm}{r_3}-c^2\right)+\sqrt{\left(G\frac{nm}{r_3}-c^2\right)^2-4\frac{1}{n'}\left(\frac{C2G}{r_2}+\frac{3G}{R_4 5}\right)\left[nC2G\frac{1}{n'}m^2\left(\frac{1}{r_1}-\frac{1}{r_1{}'}\right)-\frac{1}{n'}KE_{total}\right]}}{2\frac{3G}{5}}$$

$$m'=R_4\frac{-\left(G\frac{nm}{r_3}-c^2\right)+\sqrt{\left(G\frac{nm}{r_3}-c^2\right)^2-4\left(\frac{C2G}{r_2}+\frac{3G}{R_4 5}\right)\left[n'Gm^2\left(\frac{1}{r_1}-\frac{1}{r_1{}'}\right)-\frac{1}{n'}KE_{total}\right]}}{2\frac{3G}{5}}$$

$$m'\propto R_4$$

For positive discriminant,

$$n'Gm^2\left(\frac{1}{r_1}-\frac{1}{r_1{}'}\right)<\frac{1}{n'}KE_{total}$$

$$KE_{Average}>n'Gm^2\left(\frac{1}{r_1}-\frac{1}{r_1{}'}\right)$$

If $n'\left(\frac{1}{r_1}-\frac{1}{r_1{}'}\right)$ grows with time$KE_{Average}$ has to increase with time in order to maintain the positive value of thediscriminant

With objects like black holes or neutron stars the above relation is greatly facilitated.

$$m' \propto R_4$$

$$m' \propto \frac{1}{n'}$$

Case II[early stages of cosmological evolution]

$$G\frac{nm}{r_3} - c^2 < 0; \frac{n'C2G}{2r_2} \ll \frac{3n'G}{R_4 5}$$

For m' to be real discriminant has to be positive

$$n'^2\left(G\frac{nm}{r_3} - c^2\right)^2 - 4n'\left(\frac{C2G}{r_2} + \frac{3G}{R_4 5}\right)\left[nC2Gm^2\left(\frac{1}{r_1} - \frac{1}{r_1{}'}\right) - KE_{total}\right] > 0$$

Large $(additional)KE_{total}$ will be supportive towards this criterion.

If

$$\frac{3G}{R_4 5} \gg \frac{C2G}{r_2} \Rightarrow \frac{3}{R_4 5} \gg \frac{n'}{r_2} \Rightarrow r_2 \gg \frac{5}{3}n'R_4$$

If n’ is too small the mass m’ will become very large. If n’ is too large the condition $r_2 \gg \frac{5}{3}n'R_4$ will break down If n ’is too large

With small-radius objects like black holes or neutron stars the above relation is greatly facilitated.

$$m' = \frac{-Gn'\left(G\frac{nm}{r_3} - c^2\right) + \sqrt{n'^2\left(G\frac{nm}{r_3} - c^2\right)^2 - 4n'\left(\frac{C2G}{r_2} + \frac{3G}{R_4 5}\right)\left[nC2Gm^2\left(\frac{1}{r_1} - \frac{1}{r_1{}'}\right) - KE_{total}\right]}}{2n'\frac{3G}{R_4 5}}$$

$$m' = R_4\frac{-Gn'\left(G\frac{nm}{r_3} - c^2\right) + \sqrt{n'^2\left(G\frac{nm}{r_3} - c^2\right)^2 - 4n'\left(\frac{C2G}{r_2} + \frac{3G}{R_4 5}\right)\left[nC2Gm^2\left(\frac{1}{r_1} - \frac{1}{r_1{}'}\right) - KE_{total}\right]}}{2n'\frac{3G}{5}}$$

$$m' = R_4 \frac{-G\left(G\frac{nm}{r_3} - c^2\right) + \sqrt{\left(G\frac{nm}{r_3} - c^2\right)^2 - 4\frac{1}{n'}\left(\frac{C2G}{r_2} + \frac{3G}{R_4 5}\right)\left[nC2Gm^2\left(\frac{1}{r_1} - \frac{1}{r_1{}'}\right) - KE_{total}\right]}}{2\frac{3G}{5}}$$

$$m' \propto R_4$$

If n' is too large $\frac{3G}{R_4 5} \ll \frac{C2G}{r_2}$,

$$m' \propto r_2$$

At any point of time we have taken $r_1{}' > r_1$. Therefore KE will be in the outward direction. A larger KE will facilitate the process, for both cases, case I and case II. From (5) if KE is too large m' will become too large unless n is sufficiently large. With the progress of time n will increase and hence KE will be increasing m' remaining more or less the same.

Equation

$$m' = \frac{-n'\left(G\frac{nm}{r_3} - c^2\right) + \sqrt{n'^2\left(G\frac{nm}{r_3} - c^2\right)^2 - 4n'\left(\frac{C2G}{r_2} + \frac{3G}{R_4 5}\right)\left[nC2Gm^2\left(\frac{1}{r_1} - \frac{1}{r_1{}'}\right) - (additional)KE_{total}\right]}}{2\left(\frac{n'C2G}{r_2} + \frac{3n'G}{R_4 5}\right)}$$

For

$$\frac{n'C2G}{r_2} \gg \frac{3n'G}{R_4 5}$$

$$m' = \frac{-n'\left(G\frac{nm}{r_3} - c^2\right) + \sqrt{n'^2\left(G\frac{nm}{r_3} - c^2\right)^2 - 4n'\left(\frac{C2G}{r_2} + \frac{3G}{R_4 5}\right)\left[nC2Gm^2\left(\frac{1}{r_1} - \frac{1}{r_1{}'}\right) - (additional)KE_{total}\right]}}{2\left(\frac{n'^2 G}{2r_2} + \frac{3n'G}{R_4 5}\right)}$$

$$= \frac{-n'\left(G\frac{nm}{r_3} - c^2\right) + \sqrt{n'^2\left(G\frac{nm}{r_3} - c^2\right)^2 - 4n'\left(\frac{C2G}{r_2} + \frac{3G}{R_4 5}\right)\left[nC2Gm^2\left(\frac{1}{r_1} - \frac{1}{r_1{}'}\right) - (additional)KE_{total}\right]}}{2\left(\frac{n'^2 G}{2r_2}\right)}$$

$$= \frac{-\left(G\frac{nm}{n'r_3} - \frac{c^2}{n'}\right) + \sqrt{\left(G\frac{nm}{n'r_3} - \frac{c^2}{n'}\right)^2 - 4\frac{1}{n'^2}\left(\frac{nC2G}{r_2} + \frac{3G}{R_4 5}\right)\left[\frac{nC2}{n'^2}Gm^2\left(\frac{1}{r_1} - \frac{1}{r_1{}'}\right) - \frac{1}{n'^2}(additional)KE_{total}\right]}}{2\left(\frac{G}{2r_2}\right)}$$

For real discriminant

$$\left[\frac{nC2}{n\prime}Gm^2\left(\frac{1}{r_1} - \frac{1}{r_1{}'}\right) - \frac{1}{n\prime}(additional)KE_{total}\right] < 0$$

$$(additional)KE_{total} > nC2Gm^2\left(\frac{1}{r_1} - \frac{1}{r_1{}'}\right)$$

Conclusion

Some of the germinal ideas relating to cosmological expansion based on classical concepts have been discussed

References

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