Gravity and Cosmic Expansion

Key words: Gravity – dark energy – dark matter – negative pressure - neutralinos

Summary: Dark matter is very likely formed by WIMPs. Neutralinos are best candidates for WIMPs being everywhere in the universe. It is suggested that the homogene distribution of neutralinos in the universe is modified by high mass bodies so following a simple pressure relation. So, Neutralinos may act as mediator of gravity and connect dark matter with gravity. Respective to the dark energy which represents negative pressure the postulated modified distribution explains the observed accelerated expansion of the galaxies in the universe.

The kinetic energy of the galaxies supports the expansion of the universe, the potential energy of the gravity counteracts against this expansion. The available usual baryonic matter is so low, in fact 4% of the critical density, that no stop inhibition is offered to the expansion of the universe for all eternity by their gravitational energy. The main part of the matter, about 90%, is dark[1] and necessary to hold together the galaxies as they are. However, it seems that the universe probably has exactly the critical density $\Omega = 1$ as a sum of the ordinary baryonic matter, dark matter and dark energy, the latter presumably corresponds to the cosmological constant and dominates the whole universe. Also according to the theory of inflation (quick expansion of the universe at least around the factor 10^{100} 10^{-35} sec after the big bang) the universe has the critical density of $\Omega = 1$. I.e., the universe is found exactly in the borderline case between collapse and infinite expansion, so it is a closed universe. Only such a universe is flat Euclidean (an undercritical universe would have a negative bend, a universe above the critical density would have a positive bend and a negative total energy, i.e. more gravitational potential energy than kinetic energy). $\Omega = 1$ is determined nearly exactly by the BOOMERANG-mission (measurement of the fluctuations of the microwave background radiation). Still, $0.4 < \Omega < 1$ is in discussion.

Approx. 4 billion years after the big bang the accelerated expansion of the universe still hold as valid and secure, nevertheless, is not fully understood up to now. The dark matter[2] very likely is formed by WIMPs ("weakly interacting massive particles")[3]. Based upon the fact that the nature is symmetrical even at basic level, a massive but only weakly change-active partner to every known particle in the supersymmetry is postulated. Following this idea to the neutrino the neutralino is the best candidate for WIMPs. These neutralinos might make up the dark matter and are essentially larger (approx. $100 - 1000$ fold) than a proton. Neutralinos could be everywhere in the whole universe but may concentrated within the galaxies because of positive gravity force.

From the measurements of the microwave background it follows that besides dark matter there must also be dark energy. The dark energy is very likely to be a source for a repulsive force which counteracts against gravity. Dark energy is likely a source of negative mass and with it could stand for antigravity. Also it corresponds to the cosmological constant which is linked with the energy density of the spatial vacuum.

It is now suggested, that immediately after the big bang when materia and antimateria are created in nearly the same amount also neutralinos and their negative partners antineutralinos were generated . So antineutralinos with negative mass who are only weakly change-active like neutralinos are evenly distributed over the whole universe. In the spatial vacuum between the galaxies where no other materia is present they stand with there negative mass for antigravity. Neutralinos are concentrated within the galaxies because of there positive gravitation energy and positive interaction with normal positive materia so representing the dark matter.

In the view of quantum mechanics the vacuum is a boiling mass of virtual particles, which appear in pairs and disappear again too short to be measured in harmony with the Heisenberg- uncertainty- relation . This quantum movements show some kind of energy and pressure, the pressure of the vacuum being negative. According to Einstein energy and pressure are sources of gravity , the vacuum with negative pressure works repulsive. Thus vacuum energy is like a form of anti-gravity.

As a conclusion the accelerated expansion of the universe is a result of the cosmological constant represented by antineutralinos with negative mass so causing repulsive force. After the universe had reached $\frac{1}{4}$ of its today's expansion, the cosmological constant obtained a stronger position in comparison to the mass density of the universe. At that time following a phase of gravitational-conditioned delayed expansion of the universe , a phase of accelerated expansion started and extends until now. Dark energy owns energy and pressure and looks repulsive, as soon as it predominates once. The dark energy makes up about $\frac{2}{3}$ of the energy density of the universe.

The neutralinos are said to be evenly distributed throughout the universe but may be concentrated within the galaxies because of positive interaction with baryonic marteria. They are now suggested as mediators for cohesion of galaxies and clusters. It is assumed that high mass bodies may modify this homogene distribution effecting in high concentration of neutralinos in the nearby environment of high masses. So, the modified distribution of neutralinos may result in the following pressure curve (Fig.1).

$$P(x) \sim \frac{Y \cdot m}{1 + \left(\frac{X}{X_0}\right)^2} - P_u$$

- $P(x)$ = pressure as sum from pressure cause by neutralinos and negative pressure of dark energy
- Y = gravitational constant
- m = mass
- X = distance to the mass centre
- X_0 = radius of the mass
- P_0 = pressure at $x = x_0$
- - P_u = negative pressure of the universe by dark energy

So, a mass in her closer surroundings generates a positive pressure caused by neutralinos. As a result at a larger distance ($x \to \infty$) the negative antigravitative pressure P_u of the dark energy predominates:

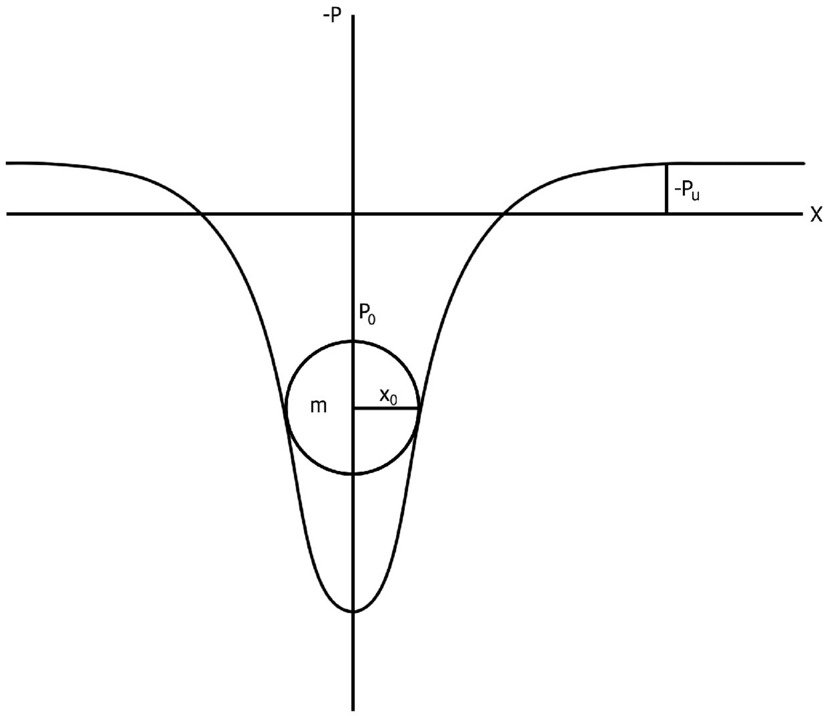

Fig.1

Or as a sum by n to m_1 neighbouring mass bodies m_z, $z \epsilon \{1, ..., n\}$ (s. Fig.2, representive for only 2 masses):

$$P(x_1) \sim \sum_{z=1}^{n} \frac{Y \cdot m_z}{1 + \left(\frac{X_1 - X_{0m_z}}{X_{0z}}\right)^2} - P_u$$

- $P(x_1)$ = pressure as sum of pressure caused by distribution of neutralinos modified by several masses m_z and negative pressure of dark energy
- Y = gravitational constant
- m_z = mass z
- X_1 = distance to the mass centre m_1
- X_{0m_z} = distance of the mass centre m_z to mass centre m_1 ($X_{0m_z} = 0$ for mass m_1)
- X_{0_z} = radius of the mass m_z
- - P_u = negative pressure of the universe by dark energy

In case the masses are in short distance the gravitative energy predominates and $P(x_1)$ is positive. In the case of 2 neighbouring masses this results in:

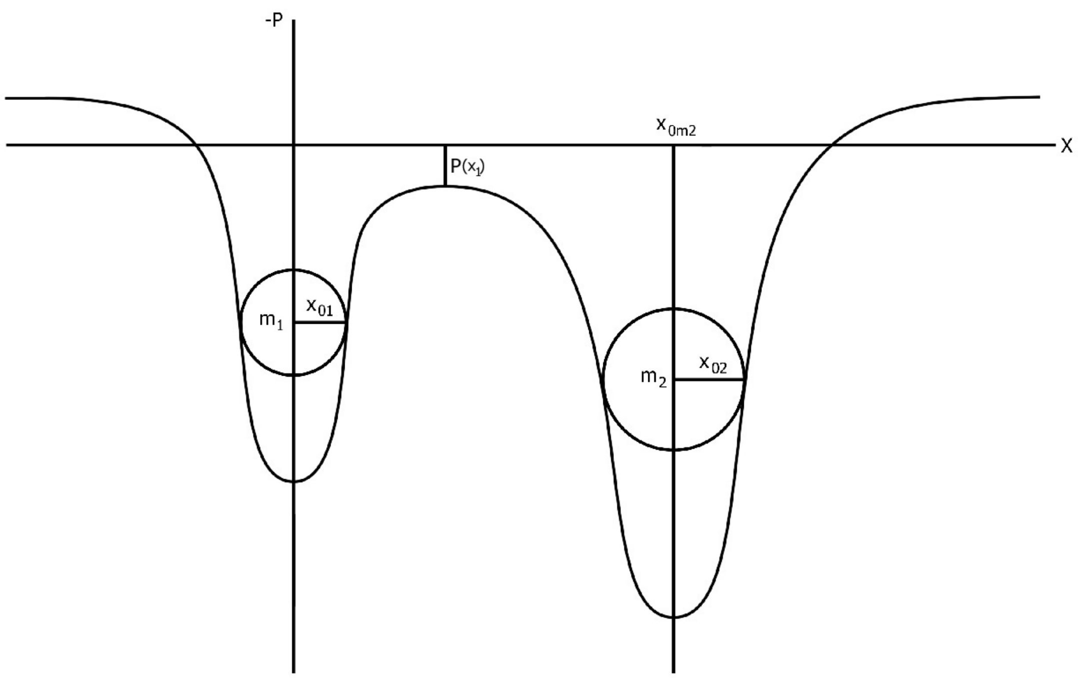

Fig.2

At a time the universe had reached $\frac{1}{4}$ of the current expansion and the distance of the galaxies/ clusters had grown further, $P(x_1)$ between the galaxies became negative (Fig.3) and therefore prevailing $(P(x_1) \to -P_u)$. As a result the dark energy (= cosmological constant) could accelerate the expansion of the universe.

$$P(x_1,t) \sim \sum_{z=1}^{n} \frac{Y \cdot m_z}{1+\left(\frac{X_1 - X_{0m_z}(t)}{X_{0z}}\right)^2} - P_u(t)$$

- $P(x_1,t)$ = time dependence of pressure caused by increasing distances $X_{0m_z}(t)$ and thereby decreasing concentration of neutralinos

For $t = 4$ billion years is valid: $P(x_1,t) = 0$ in the transfer from delayed to accelerated expansion of the universe, all other parameters are also known in detail at that time, the factor of proportionality can precisely be determined then.

Regarding $P_u(t)$ a time dependence with $P_u(t)$ is discussed: First, $P_u(t)$ going to zero is possible because of the cooling universe[4]. Second, $P_u(t)$ may go to infinite, all matter (atoms, planets, galaxies) ending in a "Big Pipe"[5]. By the way the time dependence is not consistent but imaginable.

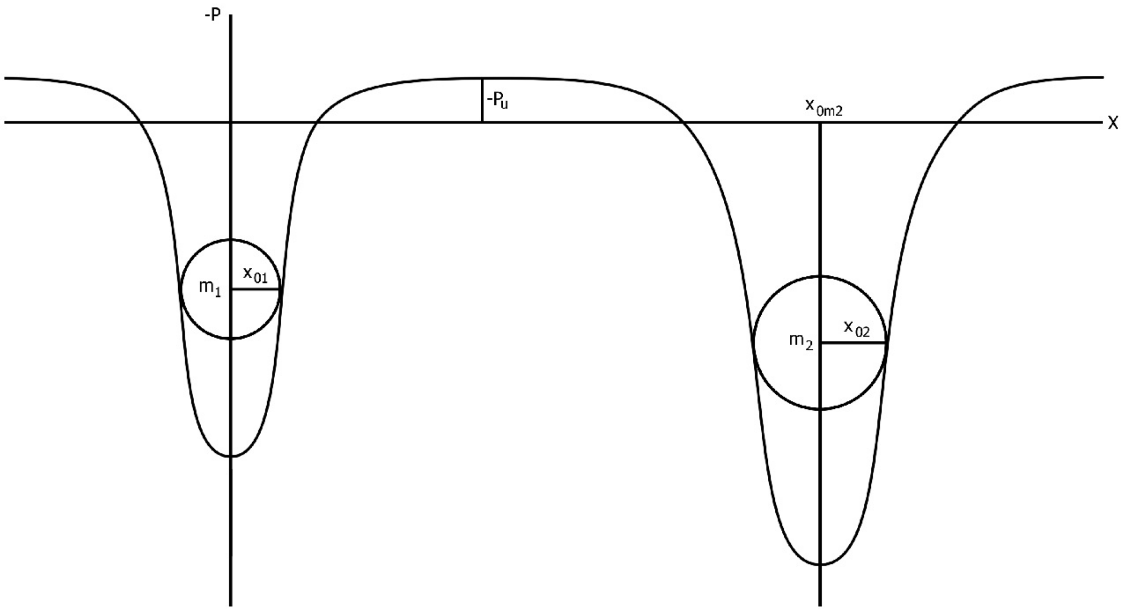

Fig.3

These considerations result in:

1. After a phase of delayed expansion an accelerated expansion[6] of the universe followed because the distance of the galaxies became so large that $P(x_1, t)$ became negative. Due to the increasing expansion dark energy (cosmological constant) gained superiority.

2. With ongoing expansion the universe will increasingly become cooler, whereby either $P_u(t)$ decreases toward zero together with dark energy, this will end the accelerated expansion of the universe ($\Omega = 1$), or P_u shows no time dependence then the universe will extend accelerated for eternity[5].

3. The gravity in the centre of a single mass body is two times greater as the value at the surface.

Literature:

1. Zornoza, J.D. et al. Dark Matter Search with the ANTARES Neutrino Telescope. *Nuclear Physics B - Proceedings Supplements Vol.* ***173*** *(2007), Pages 79-82*

2. Chase, S.I. What is Dark Matter? *physics-faq/part2. sci.physics Newsgroup. (1994)*

3. Griest, K. The Search for the Dark Matter: WIMPs and MACHOs. *Annals of the New York Academy of Sciences Vol.* ***688*** *(1993), Pages 390-407*

4. Wetterich,C. Dilatation Symmetry in Higher Dimensions and the Vanishing of the Cosmological Constant. *Phys.Rev. Lett.* ***102****, 141303 (2009)*

5. Caldwell,R.R. et al. Phantom Energy: Dark Energy with W < -1 causes a Cosmic Doomsday. *Phys. Rev. Lett.* ***91****, 071301 (2003)*

6. Riess,A.G. et al. Observational Evidence from Supernovae for an Accelerating Universe and a Cosmological Constant. *Astron.J.* ***116*** *(1998), Pages 1009-1038*

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Figure Legends:

Fig.1: Pressure curve of neutralinos whereby their distributiuon is modified by a single mass m
Fig.2: Pressure curve of neutralinos whereby their distributiuon is modified by more than one mass. Masses are in a distance where former delayed expansion took place.
Fig.3: Pressure curve of neutralinos whereby their distributiuon is modified by more than one mass. Masses are in a distance where accelerated expansion takes place because $P_u(t)$ becomes negative.