An alternative model, explaining the VLS, created by the gravitational interaction of two matter populations, one composed of positive mass and the other of negative mass.

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Abstract. Negative mass arise naturally from dynamic groups, as shown in 1970 by the french mathematician Jean-Marie Souriau. We recall this, based on the coadjoint action of the Poincaré group on its momentum. Negative populations include negative energy photons. If we admit that positive and negative mass cannot interact through virtual photons, they only interact through gravitational force. Two particules whose mass display the same sign attract each other through Newton law. Two particles of opposite signs repel each-other through «anti-Newton» law. Then the two populations tend to separate. If the mass density of the negative material is much larger, it first form clusters by gravitational instability. Then the positive matter is repelled in the remnant place, shaped like adjoining bubbles, which looks like VLS. To illustrate this scheme, we provide 2d simulation results. In addition this model provides a new insight on the galaxies' birth mechanism.

1. Introduction

Negative mass arise naturally from dynamic groups, as shown in 1970 by the french mathematician Jean-Marie Souriau [1]. He writes the momentum of the Poincaré group in the following matrix notation :

$$M=\begin{pmatrix} 0 & -s_z & s_y & f_x \\ s_z & 0 & -s_x & f_y \\ -s_y & s_x & 0 & f_z \\ -f_x & -f_y & -f_z & 0 \end{pmatrix} \qquad P=\begin{pmatrix} E \\ p_x \\ p_y \\ p_z \end{pmatrix} \qquad J=\begin{pmatrix} M & P \\ {}^tP & 0 \end{pmatrix}$$

Then he writes the coadjoint action of group on its moment as :

$$J' = g\,J\,{}^t g \qquad M' = L\,M\,{}^t L + C\,{}^t P L - L P\,{}^t C \qquad P' = L\,P$$

If one chooses a coordinate system linked to the particle, the passage vector *f* becomes zero, and the *s* vector identifies with the spin, as a purely geometrical attribute, quanticized by Souriau on geometrical grounds. The Poincaré group owns four connex components, forming two subsets : the orthochron one and the antichron one. As shown by Souriau in 1970 any element of the antichron subset transforms any orthochron movement into an antichron movement (implying a *T*-symmetry). Using the element L_o of the orthochron subset of the Lorentz group, the complete Poincaré group element, in its matrix representation, can be written :

$$g = \begin{pmatrix} \lambda L_o & C \\ 0 & 1 \end{pmatrix} \quad with \quad \lambda = \pm 1$$

The coadjoint action of the group on its momentum can be written :

$$M' = L_o M\,{}^t L_o + \lambda C\,{}^t P L_o - \lambda L_o P\,{}^t C \qquad\qquad P' = \lambda L_o P$$

which shows explicitly how a *T*-symmetry ($\lambda = -1$) deals with the inversion of the energy *E*. Then this movement refers to matter whose energy and mass are negative. In addition, if we consider the complete Poincaré group we must think about negative energy photons.

Time-inversion, in a twin universe cosmic model was first proposed by A.Sakharov in 1967 (3). Adding the Souriau's 1970 theorem we get a new dynamical system, ruled by gravitationally interacting masses, with opposite signs.

2. Electrically charged particle description.

As shown by J.M.Souriau (1) an electric charge can be added to the particle, considering its movement as inscribed in a 5d Kaluza space with signature (+ - - - -). Then the dynamic group is the following extension of the Poincaré's group :

$$\begin{pmatrix} L & C & \phi \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} \lambda L_o & C & \phi \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad with \quad \lambda = \pm 1$$

Its dimension is 11. This adds an extra scalar *q* to the momentum, identified to the electric charge, and an extra relation to the coadjoint action : $q' = q$

3. Electrically charged particle description.

As shown by Souriau, (ref.2, chapter 5) the charge conjugation ($q \rightarrow -q$) goes with the inversion of the fifth dimension ($\zeta \rightarrow -\zeta$), the Kaluza dimension. This is phrased through the following matrix representation of an extended group :

$$\begin{pmatrix} \mu & 0 & \mu\theta \\ 0 & \lambda L_o & C \\ 0 & 0 & 1 \end{pmatrix} \quad with \quad \lambda = \pm 1 \quad and\ \mu = \pm 1$$

Then antimatter corresponds to a peculiar movement of the charged mass point in a five dimensions space. The associated coadjoint action of the group on its momentum space is

$$M' = L_o M\,{}^t L_o + \lambda C\,{}^t P L_o - \lambda L_o P\,{}^t C \qquad P' = \lambda L_o P \qquad q' = \lambda \mu q$$

which shows that the ζ-symmetry ($\mu = -1$; $\zeta \rightarrow -\zeta$) goes with a C-symmetry ($q \rightarrow -q$).
This is the geometrical interpretation of the matter-antimatter symmetry

4. Could positive and negative energy particles co-exist in the same space ?

Could we think about an Universe made of positive and negative masses ? The latter would emit negative energy photons. Neither our eyes, nor our optical devices react to such negative energy light. Therefore we cannot observe such structures with our telescopes. Negative mass structures would be perfectly invisible to us. In addition there is no theory which describes the electromagnetic interaction between particles of opposite mass, so that we can assume that such interaction does not occur. These particles can therefore only interact through gravitational force.

$$F = \frac{G\,m\,m'}{d^2}$$

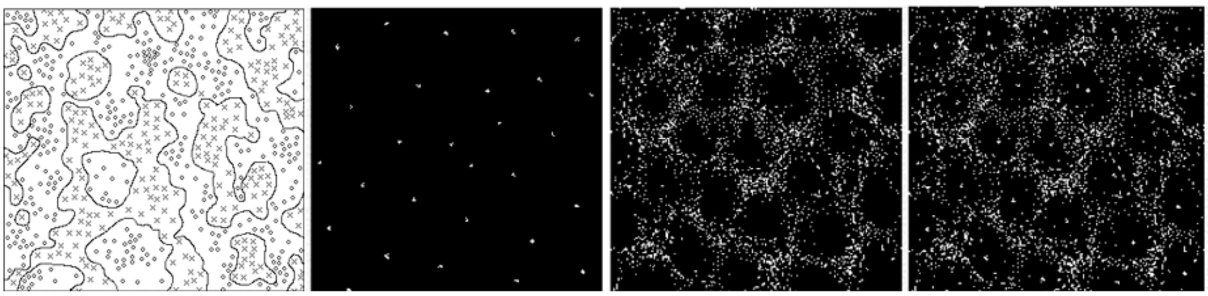
The result depends on the observer. We consider ourselves to belong to the positive mass and energy world. If two positive mass attract each other through Newton's law, positive mass is repelled by a negative mass, through the « anti-Newton law ». The action-reaction principle implies that an observer made of positive matter repels negative matter. In addition, two negative masses attract each other through Newton's law. We will consider in the following the observational consequences of such dynamics through numerical simulations.

5. Opposite mass particles interaction. Numerical results.

Consider 2d simulations. If we place two sets of positive and negative particles, with the same average random velocity and the same density, in the same space, we get a percolation phenomenon (a). [Crosses : positive masses ; circles : negative masses] Now, assume that the absolute value of the negative mass density is 50 times higher than the one of the positive mass. Then its associated Jeans time

$$t_J^- = \frac{1}{\sqrt{4\pi G|\rho^-|}}$$

becomes seven times smaller than the one of positive mass species. Negative species forms clusters (b) and repels the positive mass in the remnant space (c). In (c) the two species, are superimposed.



a b c d

Fig.1 : Results of 2d numerical simulations (4), (5), (6)

The computation (a) corresponds to 2 x 500 mass-points, and the following computations to 2 x 2000 mass points. We deal with border conditions assuming that the system is infinite and spatially periodic, like a pavestone on a floor. If L is the length of the shown square figure, each point inside interacts with all neighbour mass points, enclosed in a similar square, centered on the point. This is equivalent to consider that the computational space is flat torus-like.

This global pattern is stable in time. The cellular structure keeps the negative clusters in place. These negative clusters behave like anchors with respects to the positive matter structure which looks like joined soap bubbles.

6. Some insight on the galaxies' birth problem.

To get condensed matter objects, initially formed by gravitational instability, the problem is to evacuate the heat by emission of radiation. In proto stars, their radiative cooling is due their spherical surface. The larger the proto star the longer its cooling time. 3d gravitational instability creates spherical negative clusters, with huge mass and dimensions. Then, if the physics of negative matter is similar to ours, the associated cooling time could be larger than the age of the Universe. Even if we fundamentally cannot have optical information on such structures, as they emit negative energy photons, we can try to have some idea about what is going on there. These big clusters would emit long wavelength radiations (reddish, infrared). They would resemble to proto stars that would never ignite. Subsequently the negative world would not have stars, no heavy atoms, planets nor … life.

On the contrary, when negative clusters first form, for their Jeans time is smaller, they repel and compress the positive matter, forming a soap bubbles like pattern. This is optimum for energy dissipation by a radiative process and triggers, promotes galaxies' formation. Later, negative matter could also play a role in galaxies' confinement.

References

[1] J.M.Souriau : Géometrie et Relativité. Hermann Ed. 1964

[2] J.M.Souriau : Structure des systèmes dynamiques. Dunod Ed. France, 1970 and Structure of Dynamical Systems. Boston, Birkhaüser Ed. 1997

[3] A.D. Sakharov (1980). Cosmological model of the Universe with a time vector inversion. ZhETF (Tr. JETP 52, 349-351) (79): 689–693

[4] J.P. Petit (July 1994). The missing mass problem. Il Nuovo Cimento B, 109: 697–710.J.P.Petit : Astr. Sp. Sc

[5] J.P. Petit (1995). Twin Universe Cosmology. Astrophysics and Space Science (226): 273–307.

[6] J.P. Petit; P. Midy, F. Landsheat (June 2001). Twin matter against dark matter. International Meeting on Atrophysics and Cosmology. "Where is the matter?", Marseille, France.