Journal of Astrophysics & Aerospace Technology

Stabnikov and Babailov, J Astrophys Aerospace Technol 2017, 5:1
DOI: 10.4172/2329-6542.1000138

Research Article | OMICS International

An Addition to the Classic Gravity Interstellar Interactions

Stabnikov PA* and Babailov SP

A.V. Nikolaev Institute of Inorganic Chemistry, Siberian Branch of the Russian Academy of Sciences, 3 prosp. Akad. Lavrentieva, 630090, Novosibirsk, Russian Federation

Abstract

A composite interaction potential for a broad range of distances was proposed. It is proposed to express the interaction force as F = Mm ($\gamma \times R^{-2} + \delta \times R^{-1}$), where γ is the gravitation constant, $\delta = 2.7 \times 10^{-31}$ $m^2 \times kg^{-1} \times s^{-2}$ is an additional fundamental constant. This approach allows one to keep the description of planet rotation is star systems almost unchanged, and to explain the anomalies of the motion of stars and galaxies without attracting the notions of so-called dark matter or universal acceleration. This approach is naturally built into the general physical picture of the world in which the significance of fundamental interactions changes while the size of objects changes, from elementary particles to galaxies. This picture is based on the interdependence of fundamental interactions and the size of material objects. Thus, weak and strong coupling determine the structure and properties of elementary particles and atomic nuclei. The existence of atoms, molecules, liquids and solids is due to electromagnetic coupling. Gravitational interaction promoted the formation of star systems, while the additional interaction δ promoted the formation of galaxies. It was demonstrated by means of thermodynamics that the formation of stable orbital systems with attraction forces $F \sim R^n$ is possible within the range $-3 \le n \le -1$.

Keywords: Fundamental interactions; Gravitational potential; Galaxies; Dark matter

Introduction

Astronomy is a science in which large-scale experiments are impossible. It is only possible to observe the motion of the matter at immense distances. However, during observation time, anomalously high velocities of starts in galaxies and galaxies with respect to each other were established, as well as some other features, for example, accelerated expansion of our Universe. To explain these features of matter motion at long distances, several hypotheses were proposed, such as the dark matter, various modifications of Newton's dynamics and so on. In the present work, we propose to modify the gravitational interaction, namely, to supplement it with one more summand. The equation proposed for the force of interaction is F = Mm ($\gamma \times R^{-2} + \delta \times R^{-1}$). The value of δ is such that within the boundaries of the Solar System the contribution from this additional summand will be negligible, but this interaction will decrease not so strongly with an increase in distance, sop finally it will exceed the classical gravitational interaction and become determining at the interstellar and intergalactic distances. Our approach agrees with the previously formulated idea of supplementing the classical gravitation [1,2] and develops this idea. The introduction of this additional summand is in fact the introduction of one more fundamental interaction.

Role of fundamental interactions in the formation of material objects

It is generally accepted that there are only four fundamental interactions: strong, electromagnetic, weak, and gravitational [3]. These interactions fully determine the structure, properties and motion of material objects, from elementary particles to galaxies. Each fundamental interaction is determining within a limited range of distances in which this fundamental interaction creates a specific kind of material formations. For example, weak and strong fundamental interactions determine the properties and sizes of elementary particles and atomic nuclei. These interactions dominate at distances up to 10^{-15} m. At larger distances, they have almost no effect on the motion of matter, and electromagnetic interaction becomes prevailing. We owe this interaction the existence of material objects from atomic size ~ 10^{-10} m to the size of solid bodies. Usual size of crystals is 10^{-2} to ~ 10 m. However, this fundamental interaction rapidly weakens at a distance longer than 10^3 m because of spontaneous charge confluence. Magnetic interaction may be observed also at large distances but it is substantially weaker that the gravitational interaction. The range of distances allocated for the dominating position of electromagnetic interaction in our world is 10^{-10} to 10^3 m, that is, approximately 13 orders of magnitude. At larger distances, the gravitational interaction becomes prevailing. According to modern notions, gravitational interaction is determining till the boundaries of observable Universe, up to about 1.3×10^{26} m, that is, 23 orders of magnitude as a total, which is almost twice as large as the range allocated for the dominating position of electromagnetic interaction. Here we do not consider such exotic formations as black holes, neutron starts etc.

If 23 orders of magnitude in distance are allocated in our world for the dominating position of gravitational interaction, this fundamental interaction should form similar material objects within this range. However, it is well known that there are two types of large material formations in our Universe: planetary systems with the size from 10^{11} to 10^{14} m, and galaxies with the size from 10^{19} to 10^{22} m. These objects differ from each other in the dynamics of the motion of their internal parts. These objects are also characterized by different structures: each planet in the Solar System has its own separate orbit, while extended spiral arms are distinguished in the galaxies. These features are well known. It is this feature that allows us to assume the reality of one more kind of fundamental interaction. No stable formations are observed for a larger scale. Therefore, we suppose that the introduction of additional fundamental interactions is not justified for the time present.

***Corresponding author:** Stabnikov PA, A.V. Nikolaev Institute of Inorganic Chemistry, Siberian Branch of the Russian Academy of Sciences, 3 prosp. Akad. Lavrentieva, Russian Federation, E-mail: stabnik@niic.nsc.ru

Received October 30, 2016; **Accepted** February 15, 2017; **Published** February 15, 2017

Citation: Stabnikov PA, Babailov SP (2017) An Addition to the Classic Gravity Interstellar Interactions. J Astrophys Aerospace Technol 5: 138. doi:10.4172/2329-6542.1000138

Copyright: © 2017 Stabnikov PA, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Citation: Stabnikov PA, Babailov SP (2017) An Addition to the Classic Gravity Interstellar Interactions. J Astrophys Aerospace Technol 5: 138. doi:10.4172/2329-6542.1000138

Hypotheses proposed to explain the motion of the matter at super long distances

A complication arose in the 30-es of the past century when explaining the motion of galaxies with respect to each other. The virial theory for the classical gravitational potential ($F \sim R^{-2}$) gives the relation $2T_{kin} = -E_{pot}$ [4], where T_{kin} is the average kinetic energy, and E_{pot} is the average potential energy. This relation is excellently fulfilled for the motion of planets within the Solar System. However, T_{kin} calculated for the motion of galaxies is much larger than the half of E_{pot} estimated based on the visible masses of galaxies. Zwicky was the first to demonstrate that the velocities of galaxies in the clusters (3700 to 12000 km/s) exceed the calculated values by a factor of 50-160 [5]. To explain this fact, rather simple assumption concerning the existence of the dark matter (DM) was formulated. Indeed, some DM will provide an increase in the potential energy of attraction T_{pot}, which will allow the relation $2T_{kin} = -E_{pot}$ to be recovered. However, this will be the case only if DM would not contribute into the kinetic energy. In other words, DM should attract common matter but must remain immobile. At that time, more than 75 years ago, there had been some hope that the DM would be discovered experimentally with the help of direct methods.

Somewhat later, when spectral telescopes were invented, the speeds of rotation of stars and galaxies were determined using Doppler method. The results are shown in (Figure 1).

This is a generalized drawing characteristic of most spiral galaxies. Near the center, till some critical region $R_b \approx 8$ kpc, the speeds of star rotation around the center are observed to increase. This region of the central part of a galaxy is called Bulge. At a distance, larger than R_b, the density of the star matter in galaxy decreases, which is confirmed by the astronomic observations? In this case, the speeds of star rotation should decrease according to Kepler laws, similarly to the speeds of rotation of the planets in the Solar System (the disk curve, Figure 1). This would be in complete agreement with the predictions of the virial theory. However, it follows from experiments that the speeds of star rotation at distances larger than R_b remain almost constant till the edge of a galaxy. It follows from this fact that the larger is the distance of a star from R_b, the stronger is the deviation of its motion from Kepler laws and predictions of the virial theory. This discrepancy may be corrected by the introduction of above-mentioned DM within the galaxies [6].

However, for the speeds of star rotation around the center of a galaxy to be constant at a distance larger than R_b, it is necessary that the DM density increases from the center to the periphery (halo

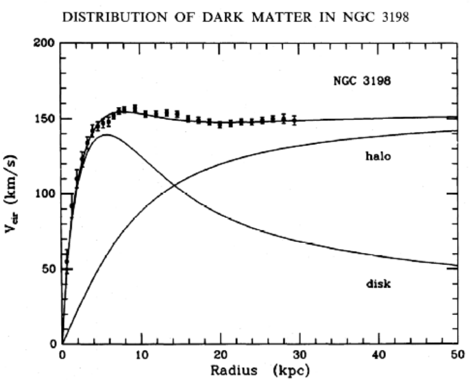

Figure 1: The dependence of the stars' rotation velocity and of dark matter distribution from distance to the center of the galaxy (from site http://bustard.phys.nd.edu/Phys171/lectures/dm.html).

Interaction mode	Gravitational (γ)	Additional (δ)
Expression for the force	$F = \gamma MmR^{-2}$	$F = \delta MmR^{-1}$
Equality in a circular orbit	$mV^2R^{-1} = \gamma MmR^{-2}$	$mV^2R^{-1} = \delta MmR^{-1}$
Expression for the square of the velocity	$V^2 = \gamma MR^{-1}$	$V^2 = \delta M$
Here m is mass of the planet or star; M is mass of the central part.		

Table 1: Orbital rotation expressions for potentials with constant γ and δ.

curve, Figure 1). Another unusual feature of the DM follows from this statement: the visible matter should be attracted to the DM, while the DM, it should experience repulsion from the visible matter because its density in galaxy center is minimal (Figure 1). This distribution of the DM within a galaxy resembles a diverging lens, and that is why the DM should scatter the light passing by, rather than collect it, while the distribution of the baryon matter in a galaxy reminds a collecting lens, so light lensing by a galaxy may be explained exclusively by the presence of usual matter alone. In general, the DM should be immobile (possessing no kinetic energy T_{kin}) and possess unusual attraction-repulsion properties.

Explicit difficulties of astrophysics in the introduction of the DM stimulated the formulation of more than 30 alternative models correcting Newton's laws and gravitation for long distances. The first one was proposed by Milgrom in 1983. Modified Newtonian Dynamics (MOND) [7], then Tensor–Vector–Scalar Gravity (TeVeS) [8], Nonsymmetric Gravitational Theory (NGT) [9,10], "dark fluid", Chaplygin gas [11], double metric tensor [12], introduction of the 7D space-time metric [13], reduction of the space dimension [2] and so on.

We propose another approach: To supplement the classical potential of gravitational interaction similarly to the way this was done for Van der Waals interaction between atoms and molecules. The basis of this approach is the consideration of the interaction as a sum of several summands; each of them makes a determining contribution at a limited distance range. Thus, for the interaction between chemically non-bound atoms and molecules, a repulsive term and up to several summands related to attraction are introduced. For the galaxy-related distances, similarly to [1], we propose to supplement the classical gravitational potential γ ($F \sim R^{-2}$) by the interaction designated as δ ($F \sim R^{-1}$) [14,15].

Potentials comparison

It follows from the (Table 1) that for the bodies interacting with a force proportional to R^{-2}, the squared velocity of their rotation around a massive center is expressed as Const/R (which is observed in the Solar System). For the bodies interacting with a force proportional to R^{-1}, the squared velocity of their rotation around a massive center is equal to a Const (which is observed for the rotation of starts at the periphery of the galaxies).

The features of interaction potentials affect the stability of the formation of orbital systems. To evaluate the stability, it is reasonable to follow the thermodynamic approach. Stability criterion for any isolated system is its internal energy. For orbital motion, the energy is the sum of the kinetic and potential energy: $U = T_{kin.} + E_{pot}$. According to the postulates of thermodynamics, if U is negative, the system is stable; if U is positive, the system is unstable. $T_{kin} = mV^2/2$ is always positive for a system. The relation between E_{pot} and T_{kin} can be easily obtained by means of the virial theory based on the equality of centripetal ($F_{cp.}$) and centrifugal ($F_{cf.}$) forces at the orbit: $F_{cp.} = F_{cf.}$. Solution of this problem for the systems with linear and inversely proportional attraction functions was presented in [4]. According to this solution, the relation between T_{kin} and E_{pot} is written as $2T_{kin} = k \times E_{pot}$, where k is the degree of radius-

Citation: Stabnikov PA, Babailov SP (2017) An Addition to the Classic Gravity Interstellar Interactions. J Astrophys Aerospace Technol 5: 138. doi:10.4172/2329-6542.1000138

k	Force of attractivity	$E_{pot.}$	The equality of forces	Virial theorem	$V^2 = 1/2$ Mtot v^2.
3	$F_3 = G_3 mMR^2$	$\frac{mv^2}{R} = G_3 mMR_2$	$\frac{mv^2}{R} = G_3 mMR_2$	$2E_{kin} = +3E_{pot}$	G_3MR^3
2	$F_2 = G_2 mMR$	$E_2 = \frac{G_3 mMR^3}{2}$	$\frac{mv^2}{R} = G_1 mM$	$2T_{kin} = +2U_{pot}$	G_2MR^2
1	$F_1 = G_1 mM$	$E_1 = G_1 mMR$	$\frac{mv^2}{R} = G_1 mM$	$2T_{kin}. = +U_{pot}.$	G_1MR
0	$F_0 = \frac{\delta mM}{R}$	$E_0 = \delta mM \mathrm{Ln}(R)$	$\frac{mv^2}{R} = \frac{\delta mM}{R}$	$2\mathrm{Ln}(R)T_{kin}. = +U_{pot}.$	δM
-1	$F_{-1} = \frac{\delta mM}{R^2}$	$\frac{mv^2}{R} = \frac{\gamma mM}{R^2}$	$\frac{mv^2}{R} = \frac{\gamma mM}{R^2}$	$2T_{kin}. = -U_{pot}.$	γMR^{-1}
-2	$F_{-2} = \frac{g_{-2} mM}{R^3}$	$E_{-2} = \frac{-g_{-2} mM}{2R^2}$	$F_{-3} = \frac{g_{-3} mM}{R^4}$	$2T_{kin}. = -2U_{pot.}$	$G_{-2}MR^{-2}$
-3	$F_{-3} = \frac{g_{-3} mM}{R^4}$	$\frac{mv^2}{R} = \frac{G_{-3} mM}{R^4}$	$\frac{mv^2}{R} = \frac{G_{-3} mM}{R^4}$	$2T_{kin}. = -3U_{pot.}$	$G_{-3}MR^{-3}$
M and m - Mass of bodies; V - Velocity of the orbital motion; γ, δ and G_k - Constant interaction; k - Degree radius vector (R_k) in terms of potential energy.					

Table 2: Some of the expressions for different potentials.

vectors (R^k) in the expression for the potential energy (Table 2). Only the case of k = 0 is not considered in [4]. The solution for k = 0 was reported in [14]. Thermodynamic stability of orbital systems depending on the interaction potential was discussed in [16].

For the case of k = -1 (classical gravitational interaction), the rotation of a body along a circular orbit is always stable because the sum T_{kin}. + E_{pot} = -T_{kin}, that is, the sum is always negative. Moreover, such a system always has a margin of safety. For example, if the velocity of body rotation is changed because of external action, the system conserves its stability having changed the circular orbit for elliptical one. However, if the energy of translation movement larger than T_{kin} is imparted to the rotating body, only in this case the system will be destroyed.

A special case is the system for k = -2. In this case, the sum of T_{kin}. and E_{pot} for the rotation of a body along a circular orbit is equal to zero. Because of this, if orbital systems are formed for such a potential, they will be in the state of unstable equilibrium, so any external action will be able to destroy this system.

For the case of k=0, the sign of E_{pot} depends on the sign of Ln(R). For R = 0.60653 (Exp(-0.5)), the logarithm is equal to -0.5, so the sum of T_{kin} and E_{pot} is equal to zero. This is the critical value. For R<0.60653, total energy of the system is U<0, and the formation of stable system is possible. For R>0.60653, U>0, and the system is unstable. Relying on the features of this potential, the authors of [14] proposed some galactic universal unit (GUU), which can serve as a criterion of the maximal size of galaxies. If a star is situated closer to the galaxy center than GUU, then, according to the virial theory, stable rotation is possible from the energy-related point of view. If the star is situated at larger distance than GUU, the stable rotation of this star is impossible.

According to Table 2, for k ≤ -3 the formation of thermodynamically stable systems with the rotation of bodies around the center is impossible because in these cases T_{kin} is larger in the absolute value than E_{pot}, so U is always larger than zero. The formation of stable systems is also impossible for k ≥ 1, because in these cases E_{pot} is positive; therefore, total energy U is always positive. In general, the formation of stable orbital systems is possible for the range -2 ≤ k ≤ 0. These conclusions were made on the basis of the thermodynamic approach. The laws of thermodynamics are not always evident but they were developed based on the analysis of matter motion and allow reliable description of the behavior of material objects.

The listed conclusions are in some contradiction with the solutions of Bertrand's problem. This mathematical problem was put forward by J. Bertrand in 1873. In its essence, this is an inverse problem of the dynamics in the plane – search for the law of the central force based on the known properties of trajectories. J. Bertrand solved this problem : he proved that there are only two potentials with the desired properties ; these potentials are exactly Newtonian (that is, gravitational, k=-1 in our designations) and Hooke's (that is, oscillatory, k=2) potentials. Further mathematical investigations of this problem followed the route of space complication. At first, the problem was considered in the spaces of constant curvature: on a sphere and on Lobachevsky's plane. Then the extensions of this problem to various Riemannian manifolds started to be investigated. This problem was studied by J.G. Darboux, G. Koenigs, J. Neumann, H. Liebmann, P. Higgs, V. Perlick, A. Besse, V. V. Kozlov, Y. Tikochinsky, W. Killing, M. Santoprete, V. S. Matveev, A. Ballesteros, W. Bolyai, O Ragnisko etc. Many researchers studied the geometric and dynamic properties of the obtained families of Riemannian manifolds of rotation and central potentials on them. It was demonstrated that for Bertrand systems the preimage of a point could be a circle or a torus, a cylinder or a pair of cylinders.

Numerous mathematical studies showed that Bertrand's system is not always integrable because its Hamilton flows are not always full. The results obtained on the metrics on Bertrand's manifolds give the most complete (by present) answer to the generalization of the classical geometric and topological problem concerning determination of the potentials providing the reticence of the definite set of trajectories of a mass point. The major conclusion remained the same: on the analytic manifolds of rotation with the constant Gaussian curvature without equators, embedded into R^3, there are precisely two strongly closing potentials – gravitational and oscillatory. These mathematical techniques and methods of solution have broadened geometry, integral calculus, topology and other areas of mathematics. The problem of stability of orbital systems was solved by means of topology, mathematical logics, integral calculus. However, the idea of mathematical (idealized) stability is somewhat different from thermodynamic (actual) stability. Thermodynamics operates with such terms as internal energy, enthalpy, entropy etc. and allows a more reliable description of the actual matter motion. In this connection, our considerations based on the analysis of the internal energy of the system provide a more precise description of the actual stability of orbital systems. This is indirectly confirmed by the fact that no stable orbital systems with -2>k and 0<k interactions have ever been discovered in nature.

Estimates of the constant δ

To describe the motion of material objects within a broad range of distances, similarly to [1], we keep to the equation:

$$F = M \times m \times (\gamma \times R^{-2} + \delta \times R^{-1}) \quad (1)$$

The numerical values of constant δ may be estimated in different manners. For example, the author of [1] relying on logical comparisons proposes 1.7×10^{-31} $m^2 \times kg^{-1} \times s^{-2}$. In [14] we relied on (Figure 1) and chose the distance R_b = 8 kpc; in our opinion, at larger distances the additional interaction δ becomes determining. If we rely on the classical notions, the mass of the central part of the galaxy is $M = V^2R_b\gamma^{-1}$. If we accept that the major interaction at this distance is the additional interaction, then $M = V^2\delta^{-1}$. Equating these relations, we obtain: $\delta = \gamma \times R_b^{-1}$. Using R_b ~ 8 kpc = 2.47×10^{20} m, we obtain for the new constant: $\delta = 6.67 \times 10^{-11} / 2.47 \times 10^{20} = 2.70 \times 10^{-31}$ $H \times m \times kg^{-2} = 2.7 \times 10^{-31}$ $m^2 \times kg^{-1} \times s^{-2}$.

The author of [2] carried out fitting using the data on star rotation in 60 galaxies reported in [9]. Processing the data, he kept to the model equation: $F = M \times m \times (\gamma \times R^{-2} + \delta \times R^{-1} + G_1)$. To calculate rotational curves, he used the dependence of the effective mass of matter in the galaxy inside a sphere on its radius R, which he took from [9]:

$$M_{(R)} = M_s \times (R \times (R+R_b)^{-1})^{3\beta}, \quad (2)$$

Where Ms - the whole mass of the galaxy, Rb - radius «Bulge», β=1.

For two fitting parameters, he obtained the values: $\delta = (2.7 \pm 0.4) \times 10^{-31}$ $m^2 \times kg^{-1} \times s^{-2}$ and $G_1 = (3.0 \pm 1.0)) \times 10^{-51}$ $m \times kg^{-1} \times s^{-2}$. The δ value is close to our estimates. However, it should be noted that the proposed approach is based on a paradoxical and even irrational idea of sequential discrete reduction of space dimensionality at large distance [2], which is extremely difficult to imagine.

Discussion

At present, increasing number of researchers understand inconsistency of the idea of DM. However, this concept appeared to be surprisingly viable, although the existence of DM lacks unequivocal proofs for already 75 years. This fact promoted the development of numerous alternatives explaining anomalies in the movement of stars and galaxies, e.g. [1,2,7-14,17,18]. It is noteworthy that our approach based on additional summand proportional to 1/R to the classic gravity force proportional to $1/R^2$ was first suggested in 1983-1984 [18]. But at that time this approach did not gain public apprehension because it was supported only by constant velocity of star rotation at the exterior of the galaxies; besides, there was confidence that undoubted proofs of reality of DM were to be found shortly. For the last 30 years, the accuracy of the astronomical data has essentially improved, also, growing computer power allowed digital simulation of the movement of the stars in the galaxies. These simulations have shown that for correct modeling of star dynamics the classic potential γ is desirable to be complemented with the δ potential [2].

In addition, this approach is naturally built into the general physical picture of the world, in which a sequential change occurs in the significance of interaction potentials between material objects with an increase in the distance between these objects.

Conclusion

In our world, the reality of fundamental interactions is confirmed by the existence of a specific group of material formations. Thus, the existence of elementary particles and atoms confirms the reality of weak and strong coupling. The existence of atoms, molecules, nanoparticles, liquids and solids confirms the reality of the electromagnetic interaction. The existence of planetary systems confirms the reality of gravitational interaction γ, while the existence of galaxies confirms the reality of additional interaction δ. This approach is natural, rather easy and understandable for a broad range of researchers, even those whose interests are far away from astrophysics.

References

1. Rimsky AA (2003) Korsakov Proceedings of the Radium Institute. VG Khlopina 10: 65.
2. Puga VA (2014) Multidimensional gravitational interaction: Galaxy rotation curves. JETP 146: 500.
3. Collegiate Dictionary (1997) Physics, A.M. Prokhorov (Ed). Moscow.
4. Landay LD, Lifshitz EM (2001) Mechanics Pergamon Press, Moscow.
5. Zwicky F (1937) On the masses of nebulae and of clusters of nebulae. Astrophys. J 86: 217.
6. Rubin V, Ford W (1970) Rotation of the andromeda nebula from a spectroscopic survey of emission regions. Astrophys. J 159:379.
7. Milgrom M (1983) A modification of the Newtonian dynamics as a possible alternative to the hidden mass hypothesis. Astrophys. J 270: 365.
8. Bekenstein JD (2004) Relativistic gravitation theory for the modified Newtonian dynamics paradigm. Phys. Rev. D 70:8.
9. Brownstein JR, Moffat JW (2006) Galaxy rotation curves without nonbaryonic dark matter. Astrophys J 636: 721.
10. Brownstein JR, Moffat JW (2007) Monthly Notices of the Royal Astronomical Society. 382: 29.
11. Li W, Xu L, Eur P (2013) Viscous generalized Chaplygin gas as a unified dark fluid. Phys. J 73: 2471.
12. Hossenfelder S (2008) Toward an AdS/cold atoms correspondence: A geometric realization of the Schrödinger symmetry. Phys. Rev. D 78: 044015.
13. Portnov YA (2014) Obtaining galaxy rotation curves without dark matter. Grav Cosmol 20: 279-281.
14. Stabnikov PA, Babailov SPA (2015) A change of the gravitational interaction on the galactic distances. Outreach 3: 137.
15. Stabnikov PA, Babailov SP, Puga VA (2016) Conference 103.
16. Stabnikov PA, Babailov SP, Puga VA (2016) Conference 168.
17. Tohline JE (1982) Proceedings of the Symposium, Besancon, France.
18. Sanders RH (1984) Anti-gravity and galaxy rotation curves. Astronomy and Astrophysics 136: L21-L23.

Citation: Stabnikov PA, Babailov SP (2017) An Addition to the Classic Gravity Interstellar Interactions. J Astrophys Aerospace Technol 5: 138. doi:10.4172/2329-6542.1000138