Inertial Systems in Relation to Accelerated Masses (or why Dark Matter is Obsolete)

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Abstract

A description of matter by a pair of spread–out waves with light velocity is derived from de Broglie's foundation of quantum mechanics. Inertia is discussed for an ensemble of masses relatively accelerated. With the resulting modified inertia, an increased rotation of galaxies is calculated (as observed; explained as gravitation effect of "dark matter" till now). Our modification of Newton's dynamics is in accordance with a wide range of observations, and obsoletes the concept of "dark matter", which has no empirical evidence apart from the effect it has on large scale objects in the universe (especially galaxies).

Introduction

De Broglie used Special Relativity on his approach to Quantum Mechanics (QM). A new interpretation of this approach is given. In this paper, we deal with one of the consequences: We quantize the relations between accelerated masses and inertial systems.

In discussion about Newton's law of inertia, Mach comes to the conclusion that this law is relative. It needs a relation to enough fixed bodies (for example to explain planet orbits, fixed stars are sufficient) [1]. For more complicated movements in the universe (especially accelerated) he requests to adapt the theory to new observations (subsection 9).

Mach dismissed the idea of space as an absolute physical structure, and assumed that the physical properties of space (especially the inertial frame) have their origin in the matter contained therein. Other ideas that have their origin in the discussion about Mach's writings here, for example those discussed in [2] are not very helpful in this discussion; though those conclusions have been verified, too (so the general idea is accepted).

We calculate the movements in surroundings of relatively accelerated stars according to the current state of astronomic observations. The effect of this insight is shown for a model spiral and a s0 galaxy (for galaxies, a rotation is observed, that cannot be explained by the visible galaxy mass. Rotation of galaxies is assumed to result of "dark matter," using Newton's law in an uncritical manner. Mach's well founded doubts were ignored). The result shows that the magnitude of acceleration is in good correspondence with observation without additional gravitation effect of dark matter.

Why has this Problem been Unnoticed for Such a Long Time?

"Laws of nature" are obtained by analyzing measurement data and forming a quantized theory thereof. The law of gravitation bases on the data obtained by Tycho Brahe, analyzed by Johannes Kepler, and generalized further by Isaac Newton; Galileo Galilei also contributed significantly to that effort by performing experiments and introducing the concept of inertial frames. This process was accompanied with a much disputed change between a geocentric and a heliocentric view of the world and the struggle between scholastic and scientific approaches to gain knowledge; altogether providing a huge leap forward for mankind — this happened roughly three to four centuries ago. The data obtained by BRAHE are data from the solar system; for obvious reasons there were no other data available at that time. Data from the solar system are still by far the most precise we have. The solar system however is a special case of gravitational law in such that more than 99.9% of the mass is in the single central star. Similar ratios are valid for other many–particle systems in the solar system (e.g. Jupiter and moons), so essentially all gravitational interactions in the solar system bog down to solving the one–particle case and applying perturbation calculation. Side–effects of many–particle systems are too small to observe.

However, the common case in the universe at large is *not* the single–particle system, it's the many–particle system of a galaxy or a cluster. Data for these are available, and don't fit well with the results of NEWTON's law of gravitation; to be more precise, this is the worst deviation between accepted theory and observation we ever had. Corrections added by EINSTEIN are only important for strong fields, but gravitation in a galaxy or cluster is very weak even compared to the solar system, so this is supposed all to follow NEWTON's dynamics.

When data don't fit the theory, either *data* or *theory* are wrong. Assuming "dark matter" to correct the distribution of matter in a galaxy to make its rotational curve fit with NEWTON's theory is correcting the *data.* However, after half a century of searching, any evidence of this dark matter other than its gravitational effect is still missing — we have a pretty good and precise model of this matter, but no trace that it actually exists. The *data* have been verified again and again, it is robust, can be obtained from various different objects in the larger universe, where similar objects have similar deviations from NEWTON's law and is in obvious contradiction to the *theory.* It contradicts the *theory* by about an order of magnitude, which is ridiculously large. The effect we are looking for is considerably stronger than gravitation, yet next to invisible in our solar system.

MACH already pointed out a problem of NEWTON's law of inertia a century ago [1]. His assumption is that NEWTON's law of inertia is only valid in a surroundings of unaccelerated masses. The major shortcoming of his argument is that the formula he provided to define inertial system doesn't lead to much different results from NEWTON's law of inertia, because masses far away contribute as much as masses nearby, and as there are many more masses far away than nearby, any effect of local accelerations would vanish.

1 The Model for a Structure Underlying Quantum Mechanics

It is possible to derive a structure underlying QM from the foundation of QM describing a particle to be spatial extended including information transport with light velocity within the particle structure.

We want to remind that DE BROGLIE laid the foundation of wave mechanics by applying LORENTZ transformation to an assumed spread out pulsation in the rest frame of a 'photon' with non–vanishing rest mass [3] (we assume this 'photon' to be a particle). Such a pulsation everywhere simultaneous in a given frame seemed absurd as a physical entity, and so this assumption seems to be forgotten. But it makes sense if we realize that this pulsation can be described by the superposition of two elementary waves with light velocity,[1] one of them moving in direction of the center of the particle, the other moving outward forming a stationary state. The frequency of one of the waves has to be assumed to be negative.

For a moving particle, taking covariant frequency

$$\frac{\omega}{2\pi} = \nu = \frac{\nu_0}{\sqrt{1-\beta^2}} \tag{1}$$

the superposition results in

$$\begin{aligned} \psi(t,x) \quad &\propto \quad \exp\left(\pm i\omega(1+\beta)\left(t-\frac{x}{c}\right)\right) + \\ &\qquad \exp\left(\mp i\omega(1-\beta)\left(t+\frac{x}{c}\right)\right) \qquad (2) \\ &= \quad 2\cos\left(\pm\omega\left(t-\beta\frac{x}{c}\right)\right) * \end{aligned}$$

[1] actually with arbitrary velocity, but we choose light speed for purpose

$$\exp\left(\pm i\omega\left(\beta t - \frac{x}{c}\right)\right)$$

with

$$\omega/2\pi = \nu = \frac{m_0 c^2}{h\sqrt{1-\beta^2}} = mc^2/h \tag{3}$$

using $\lambda_C = h/mc$ and $\lambda_B = h/mv$ we get de Broglie's wave as envelope of the interference:

$$\psi(t,x) \quad \propto \quad \cos\left(\omega t - 2\pi\frac{x}{\lambda_B}\right) * \tag{4}$$
$$\exp\left(\pm i\beta\omega t \mp 2i\pi\frac{x}{\lambda_C}\right)$$

With this model, DE BROGLIE's assumption of particles that are spatial extended becomes more plausible. Our interpretation is that we have a description of the interaction of the particle — thus the interaction function ψ will spatially diminish with $\frac{1}{r^2}$. We assume interaction of the particle may be described by interactions with the two elementary waves. Moreover the two waves transform separately with LORENTZ transformation. We will now apply this model for long–range interactions.

Note: This model has consequences for the interpretation of QM (e.g. the Copenhagen interpretation), which are to be discussed elsewhere.

2 Inertia with an Ensemble of Masses Relatively Accelerated

The description of a particle by the superposition of two elementary waves contains the assumption, that the physical entity of the particle is described by a symmetric wave function in coordinates at rest relative to the particle. Interactions are supposed to disturb this symmetry, but we suppose the possibility to reestablish the symmetry by a transformation due to the DOPPLER shift for both waves.

The definition of interactions that follow the standard model of particle physics is easy; these interactions change the state of the particle, but don't influence space–time — the standard model is very successful, so we suggest to keep the interactions as described there; but to extend it towards gravitation. The question therefore is how to define interactions that modify space-time, and this leads to the question how space–time, i.e. the coordinate system or space–time, is actually defined. It is proposed that this coordinate system is defined by all elementary waves (of mass) in universe.

Analog to the conservation of energy for electromagnetic waves, we propose an equivalent conservation $\sum A_0\vec{k}\nu$ for all elementary waves crossing a mass–free space element. In other terms,

$$\operatorname{div}\sum A_0\vec{k}\nu = 0 \tag{5}$$

defines an inertial frame. This is obvious for an inertial frame for waves originating in unaccelerated sources. We generalize this equation for waves originating in relatively accelerated sources supposing the locally observable variables determine inertial frames also in this case.

We ask for the consequences in nearly EUCLIDean space, and mass points far away. There, the changing of amplitude A_0 in space will be neglectable. For a single mass point accelerated by $\vec{a}$, the sum of the product of the wave vector $\vec{k}$ and the frequency ν of both elementary waves changes in space by retardation proportional to $\vec{a}$ for both the longitudinal component due to first order DOPPLER shift and the transversal component due to the aberration effect, i.e. $\vec{a} = \operatorname{div}(\vec{k}\nu)$. This model is consistent with NEWTON's law in an environment of not accelerated masses, because $\operatorname{div}\sum A_0\vec{k}\nu$ is zero for $v = \text{const}$ (in empty euclidean space — "empty" means that all waves are from very far away, and therefore not diverging). Of course, for non–empty space, this term is non–zero, and demands an acceleration which we know as gravitation — this part is well–known, so let's take it out.

With the amplitude $A_0 \propto \frac{M}{r^2}$ (corresponding to gravitation), we get for several relatively accelerated mass points

$$\sum_i \frac{M_i\vec{a}_i}{r_i^2} = 0 \tag{6}$$

to be the definition equation for the inertial frame (in euclidean space, i.e. weak field approximation, already free falling, i.e. gravitational divergence of the term above eliminated).

3 Calculation of Acceleration for a Model Spiral Galaxy

The effect of this definition equation (6) is shown for a model spiral galaxy. For galaxies, a rotation is observed, that cannot be explained by the visible galaxy mass (an overview is found in [4]). A still greater mass discrepancy is observed for groups of galaxies and clusters. We make a calculation for a galaxy, because the effect is well known and sufficient data are available. These first assumptions contain a significant amount of hand–waving, and are made to make a qualitative evaluation, if the model is feasible at all.

In this model galaxy mass distribution is:

Bulge distribution in an ellipsoid ($r_{\text{center}} \approx \frac{1}{4} r_{\text{galaxy}}$, $M_{\text{center}} = \frac{1}{3} M_{\text{galaxy}}$), relation of axis is 1:3.

Spiral arms Two spiral arms are assumed. Stars are distributed arbitrary. Each spherical shell of the galaxy contains the same mass. In the plane of the galaxy we take a Gauss distribution, in the vertical direction extension reduces with $\frac{1}{r}$, the vertical distribution is also non–uniform (square of a uniform random number). We assume that the visible spiral arms actually reflect density differences in the galaxy, whereas the standard theory can not explain how these structures remain stable, and therefore assumes uniform matter distribution.

The rest of the universe is assumed with radius $r_{\text{universe}} = 2 * 10^5 r_{\text{galaxy}}{}^2$, consisting of 10^{11} galaxies, out of which 10% are big galaxies (the others don't contribute much to the mass), uniformly distributed. No acceleration is assumed between the galaxies.

The result of the calculation is shown in Figure 1 with different colors indicating the relation of total acceleration to static gravitation effect towards the center of the galaxy. Mass distribution is shown by lines of equal density.

[2] $r_{\text{galaxy}} := 20\text{kpc}$, $r_{\text{universe}} := 4\text{Gpc}$

Variation of relation of galaxy mass to mass density of the universe by factor 2 does change the relation of acceleration by less than 20%. Main parameters are radial mass distribution and the density of the spiral arms of the galaxy.

Figure 2 shows a number of curves obtained from the calculation:

cyan The rotation speed assuming gravitation only, scaled to match observation

yellow The rotation speed assuming our theory and the same mass as the cyan curve

green The rotation speed scaling down to match observation

magenta The acceleration using gravitation only

red The acceleration using our theory, scaled same as the magenta curve

The red and yellow numbers show the relations between acceleration and rotation speed at the selected radius.

The x axis is divided into 1e20m per square, the y axis into 100km/s per square. Assuming circular orbit of the spiral arms of a galaxy the result for total acceleration is consistent with the observation that the inner part of a spiral galaxy rotates like a solid disk — otherwise the bar structure would not last long. Our theory explains why a galaxy with a bar-like spiral arm structure is stable. However, this analysis is a purely qualitative one, as we lack data backed by astronomers for the above mentioned theoretical reasons. If we assume a more evenly spread out distribution of masses (not concentrated into the bar and spiral arms), we get a weakened effect, which would not result in a solid disk like rotation, but rather one that is comparable to a S0 galaxy (which is in good coincidence with observation).

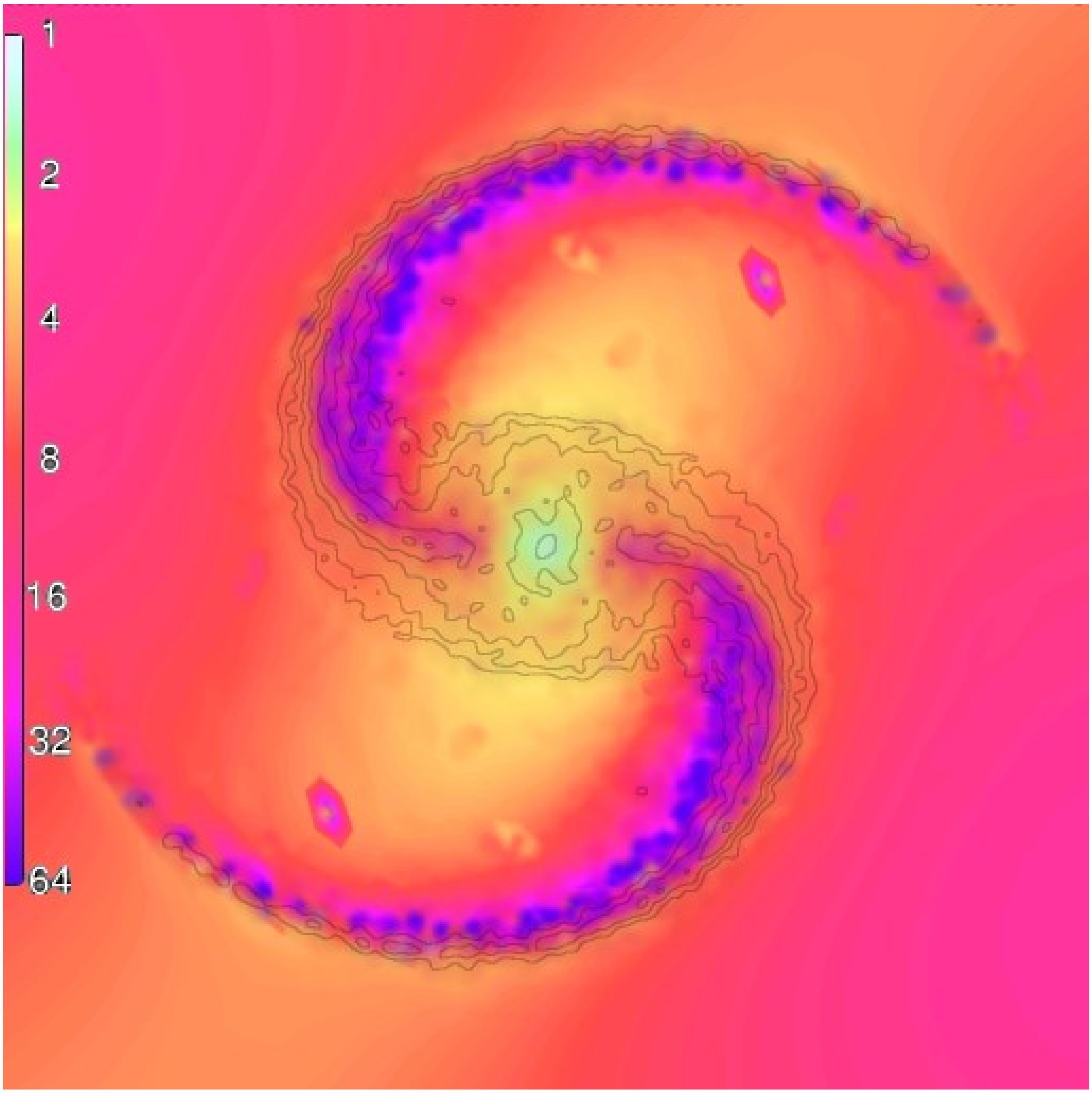

Figure 1: $a_{\mathrm{total}}/a_{\mathrm{gravitation}}$ calculated for a model spiral galaxy

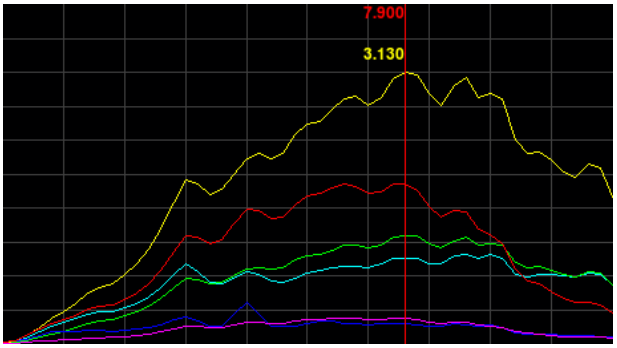

Figure 2: Gravitation and total acceleration for a model spiral galaxy

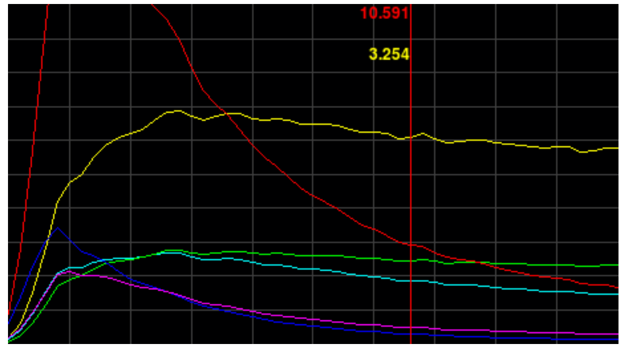

Figure 3: Gravitation and total acceleration for an s0 galaxy

A less dense elliptical galaxy, not flattened as disk and without spiral arm structure shows a much smaller difference between gravitational and total acceleration, as observed by ROMANOWSKY et al. [5].

4 Calculation of Acceleration for a Model S0 Galaxy

The calculation for a spiral galaxy looks reasonable, but unfortunately, we have no astronomical evidence that our assumed mass distribution is correct. Furthermore, spiral galaxies contain a significant amount of mass in form of gas and dark clouds, and the distribution of mass within a spiral galaxy as assumed by us is at least somewhat controversial. So we asked an astronomer for better (and less controversial) data — which he gave us for the case of a S0 galaxy (where stars are more uniformly distributed and gas doesn't play an important role) [6]. The model was as follows:

Bulge with $6e9\odot$, distribution as above

Disk with $6e10\odot$ within $R = 10\,\text{kpc}$, and surface density of $\Sigma(R) = \Sigma_0 * e^{-R/R_e}$, $R_e = 3.5\,\text{kpc}$, and a thickness of 200 pc (which is considerably less than the assumption above, and increases the effect)

Figure 3, colors as described above, shows rotation with a purely gravitational model (cyan, scaled up to approximately match observation) and calculated rotation with our theory, using the same assumed mass as for gravitational rotation (yellow). The x axis is again divided into 1e20m per square, the y axis into 100 km/s per square. We assume the mass distribution is obtained from the kinematics of the observed galaxy, and not through measurement of the actual masses (e.g. star counts and classification), i.e. the visual mass contributes only 10% to the "actual mass" using the CDM[3] model, and about 100% using our model. The actual relation between mass and observed light emission from the galaxy therefore is presumed unknown. Scaling the calculated rotation down to observed values at ~10 kpc gives a basically flat curve with about 250 km/s rotation towards the outer rim of the S0 galaxy (green) — this is in good correspondence with observation, and contradicts a pure NEWTONian model, where the outer rim would rotate with only 150 km/s (cyan).

5 Bullet Cluster

Our theory does modify NEWTON's dynamics. Other modifications have been proposed, especially by MORDEHAI MILGROM [7]. The bullet cluster observation however clearly contradicts with MILGROM's predictions. This did lead to bold statements that the

[3]cold dark matter

bullet cluster is an empirical proof of the existence of dark matter [8], which is not quite conclusive. Of course, it is a test any theory of galaxy rotation must pass, i.e. the only viable theories are those which can explain the bullet cluster observation. Those clearly rule out ultra–weak field deviations of gravitation law.

However, this observation does not contradict with *our* predictions, rather the contrary. The bullet cluster consists of an unstructured plasma cloud, and structured spiral galaxies. The unstructured plasma clouds do not show any significant deviation from standard gravitation theory, which we expect, because the plasma clouds don't have significant internal accelerations. On the other hand, the spiral galaxies show the usual abnormal high acceleration effects, which is fully explained by our theory.

6 Conclusion&Outlook

The result of the calculations of inertia for galaxies shows that the rotation curve is in good correspondence with observation without the assumption of additional gravitational effect of dark matter, which has been an open question to physics for the last 80 years. Furthermore, a better understanding of formation of galaxies and of the dynamics of clusters will be possible. We are working on testing our theory further with small deviations from gravitation observed in the solar system, e.g. the fly–by anomaly. This is however more difficult than galaxy rotation, because the effect is so small.

Our theory does not contradict the well–established and tested standard model of particle physics, and not only allows to extends it to gravitation (as it contains a mechanism how matter can modify space–time), but also explains why large cosmological structures show a much higher acceleration than expected. This is a clear and substantial progress over the ΛCDM model.

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