The introduction of the entraining force and its consequences for the interpretation of red-shift

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Abstract

The main intention of this paper is to start an open discussion about a new model with the potential to find a better understanding of several observations within astronomy. As a first step a model of an entraining force is introduced based on the observation that the distances between earth and moon respectively earth and sun are slightly increasing over the year. Based on further explanation on how to calculate the entraining force and its corresponding counter-torque similar to law of induction but for moving matter. Further on an outlook is given about how this force may contribute to a better understanding about how accretion disks or planetary ring systems are forming or how it may drive the differential rotation on the surface of gas giants but also within galaxies related to their rotary curve. In a second step the consequences of the concept are described related to the current interpretation of red-shift. If the model of the entraining force will be further verified the concept of the expanding universe might have to be revised.

Contents

1 Motivation

Current approaches to find evidence of the the existence of dark energy or dark matter remain unsuccessful. Therefore some astronomers started the search for *the one better idea* [1, 2, 3, 4]. Potentially I found one. After viewing a partial eclipse of the sun I started to figure out the next date of a total eclipse that will be visible for me. Being disappointed that solar eclipses are rare and will become even more seldom as the distance between moon and earth is slightly increasing I was stuck by that one question: *Why*? For whatever reason is that happening? How can it be that the distance is increasing without any force described pointing into the right direction to do exactly that?

I started my research based on information I found occasionally on the internet and found other unexplained discrepancies like the rotation curve of galaxies or the differential rotation of gas giants [5, 6].

Finally I had the idea of an entraining force and developed a model that might be suitable to explain the increasing distance between earth and moon but will also have an impact on the current interpretation of the red-shift of light from the deepest universe.

The model itself is quite similar to newtons law of gravitation [7]. It's just not based on the difference of positions but based on the difference of velocities, where the difference of velocities is also regarding the aspect of the rotation of a body as shown in figure 1.

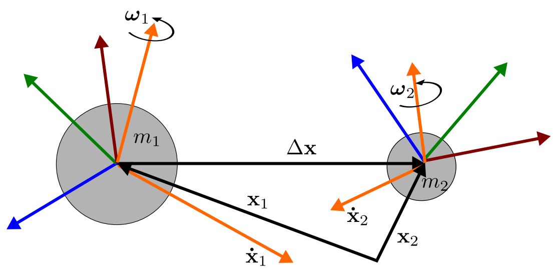

Figure 1: Two bodies with mass m_i with at distance $\mathbf{r} = \Delta\mathbf{x}$ moving with velocity $\mathbf{v}_i = \dot{\mathbf{x}}_i$ and rotational speed $\boldsymbol{\omega}_i$

The masses m_i have a distance of $\mathbf{r}_{12} = \mathbf{x}_2 - \mathbf{x}_1$ and are moving translational by a speed of $\dot{\mathbf{x}}_i$ while rotating with a speed of $\boldsymbol{\omega}_i$.

2 Observed discrepancies

On the way to the answer to my special „*Why?*" I considered the cosmological expansion of the universe and some explanations based on the conservation of angular momentum. I decided to bring in a new model afterwards.

2.1 Cosmological expansion

Independent from the accurate value of the Hubble constant H_0 I follow the assumption that it should apply within the whole universe [8]. Therefore it should apply also within our solar system which might be a good explanation of an increasing distance between earth and moon.

With $H_0 \approx 70km/(sMpc)$, 1 Megaparsec $= 3.09\text{E}19km$ and the duration of one year $1a = 31.56\text{E}6s$ we get a rate of expansion of 7.57E-11 per year:

$$H_0 \approx \frac{70km}{sMpc} = 7.57\text{E-}11\frac{1}{a} \tag{1}$$

That means each kilometer of distance will increase annually by 7.57E-11km through cosmological expansion. The *Lunar Laser Ranging Project* proved over a period of 40 years that the moon displaces approximately 0.038m each year [9].

A paper about the secular increase of the astronomical unit [10] describes a value for an increasing distance between earth and sun to be $dAU/dt = 15 \pm 4(m/cy)$.

Table 1 shows for the cosmological expansion for the distances $\|Earth - Moon\| = 384400km$ and $\|Earth - Sun\| = 150000000km$ compared to the observed values.

	Earth–Moon @ 0.38E6 km	Earth–Sun @ 150E6 km
expected	0.029m/a	11.3m/a
observed	0.038m/a	0.15m/a

Table 1: observed cosmological expansion within solar system compared to expectation by H_0

The observed value for the increase of distance between earth and moon is at least in the same scale as the expected value. This does not apply to the observed value for the earth-sun–system. It is far to small. It seems that cosmological expansion is not applying in our solar system. As a consequence it may also not be used as an consistent explanation for the increasing distance between earth and moon.

2.2 Conservation of angular momentum

A common explanation for the recession of the moon is the conservation of the angular momentum: If the earth rotation speed is decreasing due to tidal friction the moon has to increase its distance to conserve the angular momentum of the earth–moon–system [11].

Within this argumentation there is a logical reversion. It is as saying: *it is raining because the street is getting wet.* It is obvious that it is not raining because the street is wet. It is the other way round: *the* *street is wet because it is raining.* The root cause for the rain is a too high humidity.

The street getting wet is a consequence but not the reason. Mathematically speaking:

$$A \implies B \neq B \implies A. \tag{2}$$

So it behaves with the conservation of the angular momentum. The conservation of angular momentum is the consequence of forces within the isolated system but not the reason. The conservation of angular momentum applies for a isolated system when no external torques are applied.

The example of a figure skater turning his pirouettes might provide further insight. Arms and legs are mechanically coupled to the body. Therefore the figure skater can be considered as an isolated system and the turning speed varies with the positions of arms and legs. Moving the arms away will decrease the turning speed and vice versa.

The angular speed of earth is decreasing by the external force of tidal friction. The only force between earth and moon is the gravitation. It is strictly pointing radial from moon to earth and has therefore no ability to increase the distance. A force is missing to do exactly that. It should be radial in the opposite direction of gravity or at least tangential to enable the recession. The angular momentum of the earth-moon-system can only be conserved if a force or torque applies that couples earth and moon regarding their angular motions.

Even if tidal friction from gravity is able to decrease the angular velocity of earth its only producing thermal energy. There is no component of that force to lift up the moon by $3.8cm/year$.

My approach to explain the recession of the moon is based on the postulation of a tangential force that has a similar impact as the Lense-Thirring-Effect [12]. In contrast to the Lense-Thirring precession my model is not based on a twist in the space-time-continuum but on a new force.

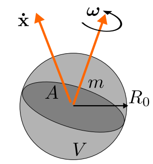

Figure 2: entraining monopol with mass m, area A, volume V, velocity $\dot{\mathbf{x}}$, turning speed $\boldsymbol{\omega}$, and a volumetric mean radius R_0

3 The entraining force

The entraining force is defined in analogy to the well known force of gravity:

$$\mathbf{F}_{\text{gravitation}} = -G\frac{m_1 m_2}{r^3}\Delta\mathbf{x}. \tag{3}$$

Instead of differences of the position $\mathbf{r} = \Delta\mathbf{x} = \mathbf{x}_2 - \mathbf{x}_1$ also the differences of the velocities $\Delta\mathbf{v}$ are regarded by

$$\Delta\mathbf{v} = \underbrace{(\boldsymbol{\omega}_1^* \times \mathbf{r})}_{\text{rotation}} + \underbrace{(\dot{\mathbf{x}}_1 - \dot{\mathbf{x}}_2)}_{\text{translation}} \tag{4}$$

according figure 1 where $\boldsymbol{\omega}^*$ represents the rotational speed in world coordinates.

To derive the force I postulate an entraining monopol of a spherical mass m with a volume V, a plane $A \perp \omega$ as displayed in figure 2 as

$$\mathbf{g} = \frac{mA}{V}((\boldsymbol{\omega}_1^* \times \mathbf{r}) + \dot{\mathbf{x}}) \tag{5}$$

$$= \frac{3m}{4R_0}((\boldsymbol{\omega}_1^* \times \mathbf{r}) + \dot{\mathbf{x}}) \tag{6}$$

generating a field

$$\mathbf{G}(\mathbf{r}, \dot{\mathbf{x}}, \boldsymbol{\omega}) = \frac{\mathscr{G}}{r^2}\mathbf{g} \tag{7}$$

The field generated by mass m_1 applied to a mass m_2 gives the force in analogy to newtons law:

$$\mathbf{F}_{\text{gravitation}} = -G\frac{m_1 m_2}{r^3}\Delta\mathbf{x} \tag{8}$$

$$\mathbf{F}_{\text{entraining}} = \mathscr{G}\frac{3}{4}\frac{m_1 m_2}{R_0 r^2}\Delta\mathbf{v} \tag{9}$$

3.1 First example: initial rotation

Figure 3 displays the conditions of two masses with no initial translation velocity and mass m_1 turning with $\boldsymbol{\omega}_1 \neq \mathbf{0}$.

The angular velocity of mass m_1 generates the *actio* of the entraining force F_2 according formula 9.

$$\mathbf{F}_{\text{entraining}} = \mathbf{F}_2 = \mathscr{G}\frac{3}{4}\frac{m_1 m_2}{R_0 r^2}(\boldsymbol{\omega}_1 \times \mathbf{r} + \mathbf{0}) \tag{10}$$

The *reactio* of $-\mathbf{F}_2$ applies as torque $\mathbf{M}_1$ towards m_1:

$$\mathbf{M}_1 = \mathbf{r} \times (-\mathbf{F}_2) \tag{11}$$

In this example torque M_1 is decelerating the angular speed $\boldsymbol{\omega}_1$ and increases $\mathbf{r}$ just as it is observable in the earth–moon–system. An animation of this example is available in first video of table 4.

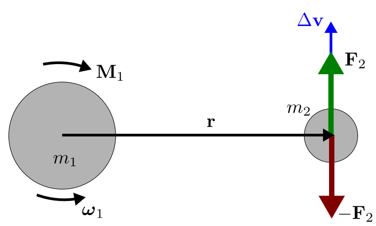

Figure 3: Force $\mathbf{F}_2$ and torque $\mathbf{M}_1$ with $\boldsymbol{\omega}_1 \neq 0$ und $\dot{\mathbf{x}}_1 = \dot{\mathbf{x}}_2 = \mathbf{0}$

3.2 Second example: initial translation

The example in figure 4 illustrates the condition with an inital translational movement without any rotation at the starting point. $\boldsymbol{\omega}_i = \mathbf{0}$

According *actio* = *reactio* the force $\mathbf{F}_2$ upon m_2 applies also as $-\mathbf{F}_2$. While m_2 gets the whole *actio* in direction of $\Delta\mathbf{v}$, the *reactio* is splitted for m_1 in force $\mathbf{F}_1$ and torque $\mathbf{M}_1$.

A consistent spread in regard of the balance of energy is achieved by dividing $-\mathbf{F}_2$ in components perpenticular and parallel to $\mathbf{r}$, as shown in figure 4. The perpendicular component is used for the torque and

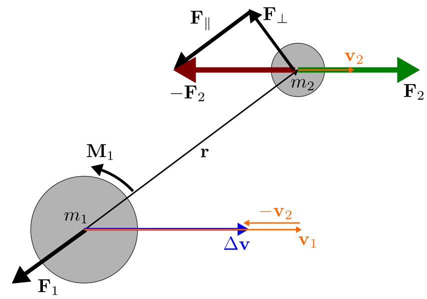

Figure 4: Force $\mathbf{F}_1$, Torque $\mathbf{M}_1$ and Force $\mathbf{F}_2$ with $\boldsymbol{\omega}_i = \mathbf{0}$ and $\Delta\mathbf{v} \neq \mathbf{0}$

the parallel amount is used for the force:

$$\mathbf{F}_2 = \mathscr{G}\frac{3m_1 m_2}{4R_0 r^2}\Delta\mathbf{v} \tag{12}$$

$$\mathbf{M}_2 = 0 \tag{13}$$

$$\mathbf{F}_1 = \mathbf{F}_\parallel = (-\mathbf{F}_2 \cdot \hat{\mathbf{r}})\hat{\mathbf{r}} \tag{14}$$

$$\mathbf{M}_1 = \mathbf{r} \times \mathbf{F}_\perp = -\mathscr{G}\frac{3m_1 m_2}{4R_0 r^2}(\mathbf{r} \times (-\mathbf{F}_2 - \mathbf{F}_\parallel)) \tag{15}$$

The calculation is also to be done for mass m_2 in analogy, so that also m_2 is receiving a torque as well as a force. The cumulative effect is resulting by the overlay of both calculations. An animation of this example is available in second video of table 4.

The result of the described entraining force and its counter-torque causes a behavior that can be described as *law of induction for gravity*:

Theorem 1 *A relatively moving mass induces angular velocity to another mass just as a turning mass is inducing translation towards another.*

Another animation in the third second video of table 4 shows how this induction works. Starting with just translational movement two bodies are ending up in bounded rotation.

3.3 Determination of constant $\mathscr{G}$

It is fact that earth is gaining potential energy in the gravitational field of the sun as well as the Moon is gaining potential energy in the gravitational field of earth each year which allows to calculate the power applied:

$$E_{pot} = -G\frac{m_1 m_2}{r} \tag{16}$$

$$\Delta E_{pot} = E_{pot}(r_{mean} + \Delta r) - E_{pot}(r_{mean}) \tag{17}$$

$$P = \Delta E_{pot}/31558118s = \mathbf{F}\cdot\mathbf{v} \tag{18}$$

A simpified setup will lead to a first approximation of $\mathscr{G}$.

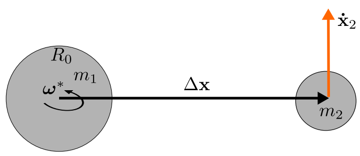

Figure 5: Simple 2D-model for determination of $\mathscr{G}$

The approximation is done by ignoring the elliptical path and just using the mean distances and velocities. The obliquity o is regarded by $\omega^* = cos(o)\omega$. With the setup as displayed in figure 5 we use

$$\Delta\mathbf{x} = \begin{bmatrix} r_{mean} \\ 0 \end{bmatrix} \tag{19}$$

$$\Delta\mathbf{v} = \begin{bmatrix} \omega_1^* r_{mean} - 0 \\ \omega_1^* r_{mean} - v_{2,mean} \end{bmatrix} \text{and} \tag{20}$$

$$\mathbf{v} = \dot{\mathbf{x}}_2 = \begin{bmatrix} 0 \\ v_{2,mean} \end{bmatrix} \tag{21}$$

and get the power $P = \mathbf{F}\cdot\mathbf{v}$ simplified to

$$P = \mathscr{G}\frac{3m_1 m_2}{4R_0 r_{mean}^2}\begin{bmatrix} \omega_1^* r_{mean} - 0 \\ \omega_1^* r_{mean} - v_{2,mean} \end{bmatrix}\cdot\begin{bmatrix} 0 \\ v_{2,mean} \end{bmatrix} \tag{22}$$

$$= \mathscr{G}\frac{3m_1 m_2}{4R_0 r_{mean}^2}\left(\omega_1^* r_{mean} - v_{2,mean}\right) v_{2,mean} \tag{23}$$

With the given values according to table 2 the values for the power evaluate as

$$P_{moon}^{earth} = 2.38527\cdot 10^{11} W \tag{24}$$

$$P_{earth}^{sun} = 1.4047\cdot 10^{14} W \tag{25}$$

By isolating $\mathscr{G}$ in equation (23) to

$$\mathscr{G} = \frac{4R_0 r_{mean}^2 P}{3m_1 m_2\left(\omega_1^* r_{mean} - v_{2,mean}\right) v_{2,mean}} \tag{26}$$

	Earth	Moon	Sun
Mass m $\left[10^{24}kg\right]$	5.9724	0.0735	1988500
Volumetric mean radius R_0 $[km]$	6371	1737	695700
Mean orbital dist. r_{mean} $\left[10^9 m\right]$	149.5	0.3844	n.a. n.a.
Recession rate Δr $[m/a]$	0.125	0.038	n.a.
Mean orbital vel. v_{mean} $[km/s]$	29.78	1.022	n.a.
Siderial rotation period $[hrs]$	23.935	655.7	609.12
ω $\left[10^{-5}/s\right]$	1.1606	0.0423	0.0456
Obliquity $[°]$	23.44	6.7	7

Table 2: Parameters used to determine $\mathscr{G}$ [13]

we obtain

$$\mathscr{G}_{moon}^{earth} = 2.17454\cdot 10^{-19}\frac{m^2}{kg\ s} \tag{27}$$

$$\mathscr{G}_{earth}^{sun} = 2.17466\cdot 10^{-19}\frac{m^2}{kg\ s} \tag{28}$$

which in both cases approximates to the known gravitational constant divided by the speed of light:

$$\mathscr{G} = \frac{G}{c}. \tag{29}$$

At least for these two applications the approach looks quite promising. Nevertheless I want to make a short crosscheck by regarding the rotational energy of earth. The increasing day time of earth by $\approx 17\mu s/a$ corresponds to lost energy.

$$E_{rot} = \frac{1}{2}I_{earth}\omega^2 \tag{30}$$

$$\Delta E_{rot} = \frac{1}{2}I_{earth}\left(\omega_1^2 - \omega_0^2\right) \tag{31}$$

With

$$\omega_0 = \frac{2\pi}{23.935hrs} \tag{32}$$

$$= 7.29195425942899\cdot 10^{-5} rad/s \tag{33}$$

$$\omega_1 = \frac{2\pi}{23.9345hrs + 17\mu s} \tag{34}$$

$$= 7.29195425799034\cdot 10^{-5} rad/s \tag{35}$$

and $I_{earth} = 8.194 \cdot 10^{37} kgm^2$ we get

$$\Delta E_{rot} = -8.5966 \cdot 10^{19} J. \tag{36}$$

As ΔE_{pot} calculates to

$$\Delta E_{pot} = P_{moon}^{earth} \cdot 31558118s \tag{37}$$
$$= 7.5274 \cdot 10^{18} J \tag{38}$$

Therefore the counter-torque of the entraining force is contributing by approximately 9% to the degression of earths turning speed. The rest goes with other the planets the sun and the tidal torque.

3.4 Centering characteristic

One further interesting property of the entraining force is its centering behavior due to the cross-product $\boldsymbol{\omega} \times \mathbf{r}$.

3.4.1 Generic example

Regarding a simple example with forces at different points P_i according figure 6 this aspect should get clearer. With

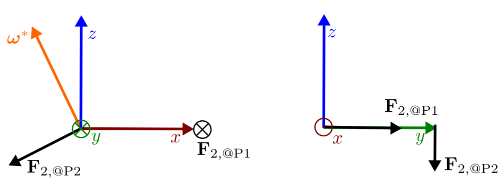

Figure 6: two perspectives of a mass m generating forces at P_i by turning with $\boldsymbol{\omega}^*$

$$\mathbf{P}_1 = [1.0,\ 0.0,\ 0.0] = \mathbf{r}_1 \tag{39}$$
$$\mathbf{P}_2 = [0.0,\ 1.0,\ 0.0] = \mathbf{r}_2 \tag{40}$$
$$\boldsymbol{\omega}^* = [-0.5,\ 0.0,\ 1.0] \tag{41}$$

the force $\mathbf{F}_2$ at the positions P_i is proportional

$$\mathbf{F}_2 \sim \boldsymbol{\omega}^* \times \mathbf{r}_1 = [0.0,\ 1.0,\ 0.0] \tag{42}$$
$$\mathbf{F}_{"} \sim \boldsymbol{\omega}^* \times \mathbf{r}_2 = [-1.0,\ 0.0,\ -0.5] \tag{43}$$

For a general point $\mathbf{P} = [x, y, z]$ with given $\boldsymbol{\omega}^* = [-0.5,\ 0.0,\ 1.0]$ we get

$$\mathbf{F} \sim \begin{bmatrix} \omega_x \\ \omega_y \\ \omega_z \end{bmatrix}^* \times \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \frac{1}{r^2} \begin{bmatrix} -y \\ x + 0.5z \\ -0.5y \end{bmatrix} \tag{44}$$

Figure 7 shows a field for the plane $z = 0$ for this example.

As a result the force is not only tangential. A small sample mass circling around the origin will get maximum push into a plane $\epsilon \perp \boldsymbol{\omega}$ at positions $x = 0$. Finally a small mass will be centered in that plane.

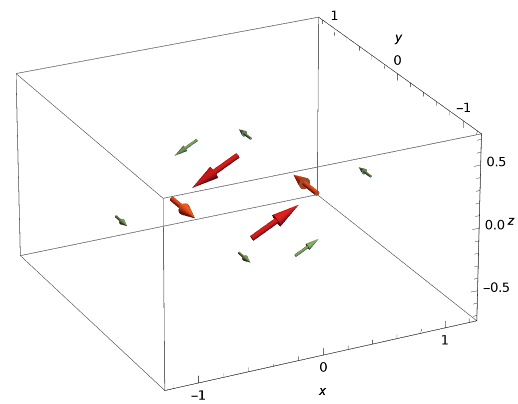

Figure 7: field of mass with inclined rotation plane $\epsilon \perp \boldsymbol{\omega}^* = [-0.5, 0.0, 1.0]$

3.4.2 Earth–Moon–System

Some pictures from simulation might deepen the insight into that aspect.

Approaches to solve the equations of motions are given by the classical mechanics. According to the generic euler-equations the relations between torque $\mathbf{M}$, inertia tensor $\mathbf{I}$, angular velocity $\boldsymbol{\omega}$ and the angular acceleration $\dot{\boldsymbol{\omega}}$ are given as follows. Let $\mathbf{I}$ be displayed in a symmetric form as

$$\mathbf{I}_1 = \begin{bmatrix} I_{1,xx} & 0 & 0 \\ 0 & I_{1,yy} & 0 \\ 0 & 0 & I_{1,zz} \end{bmatrix} \tag{45}$$

we get:

$$\mathbf{M}_1 = \begin{bmatrix} I_{1,xx}\dot{\omega}_{1,x} + (I_{1,zz} - I_{1,yy})\omega_{1,y}\omega_{1,z} \\ I_{1,yy}\dot{\omega}_{1,y} + (I_{1,xx} - I_{1,zz})\omega_{1,x}\omega_{1,z} \\ I_{1,zz}\dot{\omega}_{1,z} + (I_{1,yy} - I_{1,xx})\omega_{1,x}\omega_{1,y} \end{bmatrix} \tag{46}$$

and

$$\mathbf{M}_1 = -\mathbf{r} \times \mathbf{F}_2 = \begin{bmatrix} r_{12y}F_{2z} - r_{12z}F_{2y} \\ -r_{12x}F_{2z} + r_{12z}F_{2x} \\ r_{12x}F_{2y} - r_{12y}F_{2x} \end{bmatrix} \tag{47}$$

the equation of motion for the angular movement to be evaluated with standard Newton-Euler or Runge-Kutta-solvers.

$$\begin{bmatrix} \dot{\omega}_{1,x} \\ \dot{\omega}_{1,y} \\ \dot{\omega}_{1,z} \end{bmatrix} = \begin{bmatrix} \frac{1}{\mathbf{I}_{1,xx}}(\mathbf{M}_{1,x} - (I_{1,zz} - I_{1,yy})\omega_{1,y}\omega_{1,z}) \\ \frac{1}{\mathbf{I}_{1,yy}}(\mathbf{M}_{1,y} - (I_{1,xx} - I_{1,zz})\omega_{1,x}\omega_{1,z}) \\ \frac{1}{\mathbf{I}_{1,zz}}(\mathbf{M}_{1,z} - (I_{1,yy} - I_{1,xx})\omega_{1,x}\omega_{1,y}) \end{bmatrix} \tag{48}$$

Figure 8 shows the result of a simulation with exaggerated parameters for the whole set of overlaying forces and torques, to make the general effect of the centering trajectories visible. The nutation is not visible in the picture.

As a result of the simulation of a modified Earth-Moon-System $\mathbf{M}_1$ acts as decelerating torque leading to a reduced angular velocity of the planet while accelerating the moon away. The smaller body tends to a bounded rotation while getting closer the the rotation plane. Animations are available in video 1 of table 5 and video 3 in table 4.

3.4.3 Gas giants

The alignment close to the rotation plane is also an interesting feature for particle systems. Within simulation some sets of starting conditions showed an interesting vior.

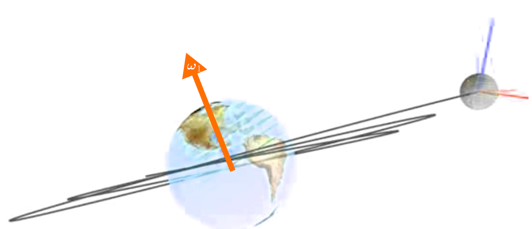

Figure 8: entraining force of planet centers moon in own rotation plane $\epsilon \perp \boldsymbol{\omega}$ while distance increases

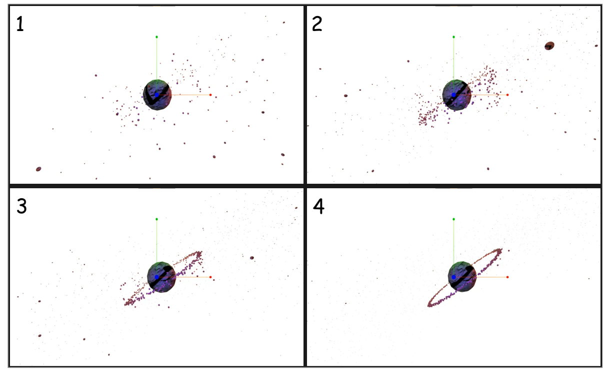

Figure 9: turning planet gathering small particles from void forming a ring in a plane $\epsilon \perp \boldsymbol{\omega}$ in the geostationary-area by application of the entraining force

Figure 9 shows a particle-system around a significantly bigger turning mass. Starting with well distributed fragments the entraining force starts to guide the fragments around the planet and to focus a part of them in a ring close to the geostationary area.

In general the approach with the entraining force seams also to be feasible to provide an explanation to accretion disks [14] or to the observation of differential rotation of gas giants [6] if a faster turning core of the planet is accelerating its surface (see simulation according table 5).

3.5 Perihelion precession of mercury

It is only a minor aspect in this paper but current predictions about the precession of mercury's perihelion show a small gap related to observations according to [15] displayed in table 3.

Even if my simulation is currently not accurate enough to give the prove of the exact value an exaggerated artificial 2-body-model can at least give a prove of concept. The example is reduced to the entraining effect only.

While sun is turning counterclockwise as well as mercury is moving the result of the simulation is displayed in figure 10. The precession is in the right direction to potentially close the gap from table 3.

Amount (arcsec/century)	**Cause**
532.3035	Gravitational tugs of other solar bodies
0.0286	Oblateness of the Sun (quadrupole moment)
42.9799	Gravitoelectric effects (Schwarzschild-like), a General Relativity effect
-0.0020	Lense-Thirring precession
575.31	Total predicted
574.10±0.65	Observed
-1.21±0.65	***Gap***

Table 3: Sources of the precession of perihelion for Mercury according to [15]

Another effect that should be observed in reality is a portion of decreasing eccentricity.

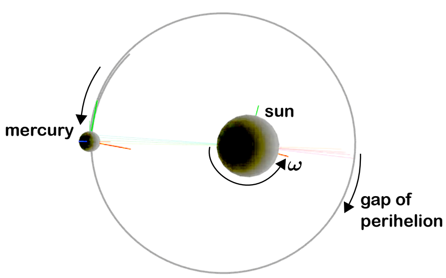

Figure 10: Artificially exaggerated sketch to show precession of perihelion due to entraining force related to the observed gap (see video in table5)

3.6 Rotation curves of galaxies

Another interesting application of the entraining force might be the explanation of the observations regarding the rotary curve of galaxies.

The observed velocities in the outer area of galaxies currently cannot be explained without introducing the model of dark matter [5]. A common property of most observed galaxies is that within the inner bulge the velocity is rising proportional by the distance.

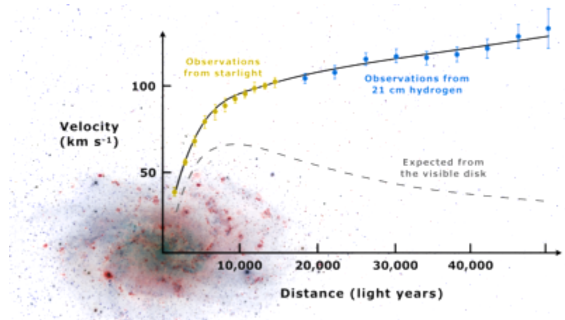

Figure 11: Rotation curve of Messier 33 modified version of Mario De Leo, license CC BY-SA 4.0 Wikimedia Commons

That is actually what is to be expected within a solid body where the angular velocity $\boldsymbol{\omega}$ is constant but the velocity $\mathbf{v}(r)$ is rising by r. In the outer area the velocity is higher than expected.

To demonstrate the potential of the concept of the entraining force an approximation is done by considering the space of a galaxy as system of rings with a height h. The spherical bulge geometry is neglected in this case.

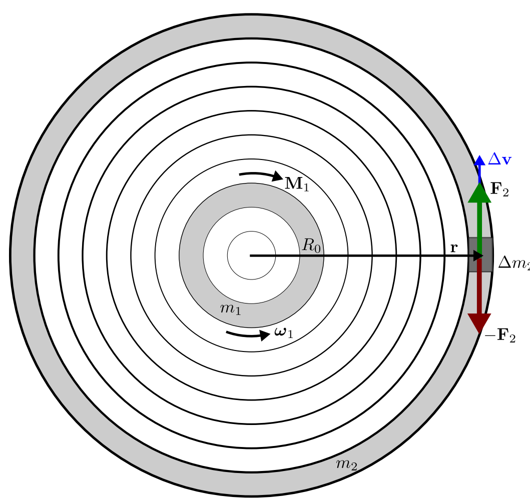

Figure 12: Galaxy approximated by rings with height h and $r_{i+1} - r_i = const$

Given a density distribution as assumed for the thin disks of galaxies of ρ over r by

$$\rho(r) = \rho_0 e^{-r^2} \tag{49}$$

the mass distribution results to

$$m(r) = \int_0^r \rho(r)\, dV. \tag{50}$$

For each ring with inner radius r_i and outer radius r_{i+1} we get for each segment a mass m_i

$$m_i = \int_{r_i}^{r_{i+1}} \rho(r)\, dV \tag{51}$$

within a volume V_i

$$V_i = \pi(r_{i+1}^2 - r_i^2)h \tag{52}$$

with an approximated $\rho_i = m_i/V_i$ as well as the inertia Θ_i for each ring i

$$\Theta_i = \frac{1}{2}\rho_i \pi h (r_{i+1}^2 - r_i^2)(r_{i+1}^2 + r_i^2) \tag{53}$$

The gravitational field for each ring i is described by

$$g_i(r) = \begin{cases} 0 & r < r_i \\ Gm_i(r - r_i) & r_i < r < r_{i+1} \\ Gm_i r^{-2} & r > r_{i+1} \end{cases} \tag{54}$$

and sums up according figure 13.

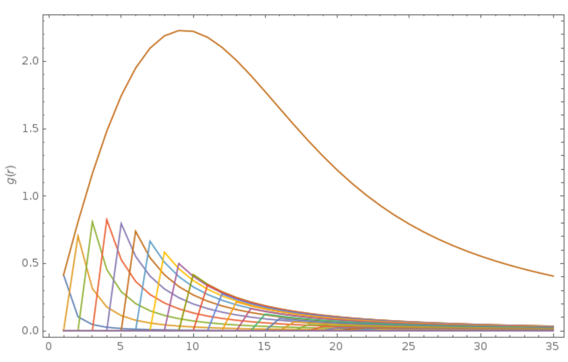

Figure 13: Field of gravitation $g(r)$ of individual rings and cumulative value

To step from the traditional field of gravitation towards obtaining the entraining field the value of Δv needs to be considered between each of the pairs of rings. Referring to figure 12 Δv equals

$$\Delta v = \omega_1 \times r - v_2 \tag{55}$$

and the veolcity v_2 of a segment Δm_2 is calculated by

$$v_2 = \omega_2 \times r. \tag{56}$$

The integral force applied to all the segments of the second ring sums up to

$$F_2 = \mathscr{G}\frac{3m_1}{4R_0}\frac{m_2}{r_2^2}(\omega_1 \times r_2 - \omega_2 \times r_2), \tag{57}$$

where

$$R_0 = r_1. \tag{58}$$

A simplification of the cross product by just regarding the plane with $\omega \perp r$ finally gives

$$F_2 = \mathscr{G}\frac{3m_1}{4r_1}\frac{m_2}{r_2}(\omega_1 - \omega_2). \tag{59}$$

The torque is calculated accordingly to

$$M_1 = -F_2 \times r_2 \tag{60}$$

which allows to calculate $\dot{\omega_1}$ and integrate ω_1. The calculation for ω_2 is done respectively.

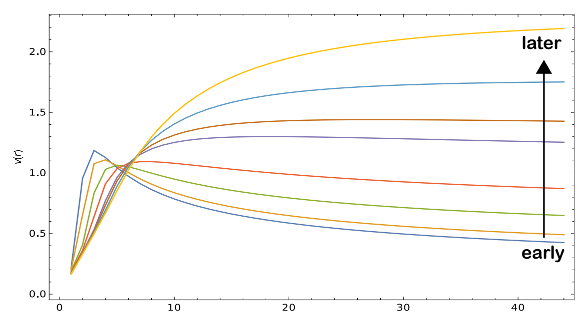

Figure 14: Development of $v(r)$ of the rotary disk over time starting with initial $\omega(r) = r^{-2}$ at the inner aera and a given density distribution $\rho(r) = \rho_0 e^{-r^2}$. A corresponding animation is accessible by table 6.

The results of the simulation show the development of $v_i = \omega_i \times r_i$. After the system is aligned it shows $v \propto r$ in the inner area and $v = const$ at the edge of the galaxy. The slight increase of v for the later stage in figure 14 is disappearing for larger values of r which not displayed in the graph. The system develops stages as described in [16]. In this model the addition of the entraining force and its counter-momentum are enough. The behavior is reached without any addition of dark matter.

4 Red-shift seen with fesh eyes

As seen in chapter *Cosmological expansion* some doubts emerge related to the Hubble-constant. A constant that is not constant is not a constant. And if the cosmological principle is valid H_0 is required to be constant also in our solar system. As this is not the case I want to consider a potential influence of the entraining force to red-shift.

Gravitational red-shift describes how light is changing it's frequency in the gravitational field [17]. I postulate that the entraining force is acting in the same manner between a quantum of light and matter. It is all a general interdependence of energy.

Light can be considered as mass and vice versa as energy according to formulas [18]:

$$E = mc^2 \tag{61}$$

$$E = \hbar\nu = \frac{hc}{\lambda} \tag{62}$$

$$m = \frac{\hbar\nu}{c^2}. \tag{63}$$

Theorem 2 *A distinction between matter and wave is not required. It is all energy and the interaction between light and matter can be considered as an energy-energy-interdependence.*

So what happens with a photon reaching us from far distance after traveling billions of years?

On the way from its source towards earth the photon passes a certain amount of particles with a relative speed of $\Delta\dot{\mathbf{x}} \approx c$. While accelerating those by a *very* small amount the photon looses a *very* small amount of energy by the entraining force.

Within a radius of $50\mu m$ around the photon a cylinder of $2.35m^3$ is build in a second while traveling with $c = 299792km/s$.

With a given density of the intergalactic medium of 1000 particles per m^3 [19] an amount of more than 2000 particles are passed in short distance each second. Within a year this counts up to 74 billion particles.

This equates finally in a half-value-period of the energy of a photon according to

$$E(t) = E_0 e^{-\kappa t} \tag{64}$$

regarding the statitical average and a constant density.

Figure 15 shows the result of a simulation with a non-constant density in small areas where the energy-loss is higher but in average decreasing by e^{-t}.

The simulation is done by calculating the entraining force on its mass-equivalent and maintaining the speed of light by regarding the change of momentum. Instead of reducing the speed the energy is changed accordingly.

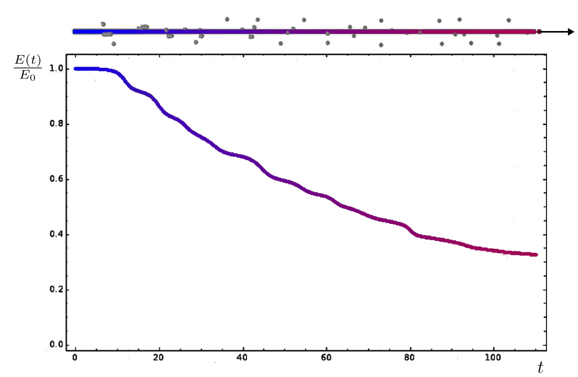

Figure 15: continously decreasing energy of a photon through the entraining force while passing particles over billions of years

Within the model the observed cosmological red-shift [17] from deepest universe is an outcome of the entraining force. After several Megaparsec the loss of energy by the entraining force is getting dominant and only red-shift is observed.

The conclusion that the observed red-shift is caused by a general expansion is not required within this model. Accordingly the expansion described by the Hubble-constant H_0 is not needed.

Further on the model of the entraining force might contribute as a root cause for the different results of H_0 in the interval of $[67, 74..73, 8] km/(sMpc)$. If the density of particles are different on the path to earth through the intergalactic space it would be reasonable that the values are different.

If the model of the entraining force proves to be valid the concept of the expanding universe needs to be revised. The search for the *dark energy* ended in finding a force hidden in the dark. No ether required: the entraining force is considered as a property of the matter itself.

So the limit of observability will be given by the initial energy of the light source. That means that the time of 13.6 billion years is currently the limit of observation of our instruments as after that time or distance the energy is reduced that far, that this is the current limit. Potentially the Webb-Telescope will allow to look even deeper and confirm the exponential decrease of energy.

The cosmological radiation is statistical distributed energy of light from fare areas reduced to almost zero by the entraining force. The filaments [20] between the galaxy clusters are build by particles accelerated to high energy by entraining force of photons coming out of the galaxies over billions of years. Video 2 in table 7 sketches this concept. While the voids are building around the old galaxies the filaments are forming up to build new galaxies like in a structure of soap-bubbles in an eternal cycle (videos 3 and 4 in table 7).

5 Conclusion

I consider the model of the entraing force as a first step into some *new* physics of gravity. I am sure that the draft of the entraining monopol is not yet perfect. Potentially slight modifications have to be done in the weight between $\boldsymbol{\omega} \times \mathbf{r}$ related to $\Delta \mathbf{v}$ in an analog manner as in *Amperes Law.* It may also be necessary to do further research regarding the near field of a mass as the initial formula is coming out of far field consideration out of the two systems $earth - moon$ and $earth - sun$. Nevertheless the concept of the entraining force provides the potential to explain several observations that have been a riddle before:

- recession of moon ✓
- secular increase of AU ✓
- bounded rotation ✓
- potential to close gap of mecury's perihelion ✓
- forming of rings around gas giants ✓
- building of accretion disks ✓
- differential rotation of gas giants ✓
- rotary curve of galaxies ✓
- explanation of high energy in filaments ✓
- new interpretation of red-shift ✓

I am eager to see whether this concept will have an impact also in the small scales of atoms and potentially lead to the one combined theory.

Any fool can know – The point is to understand
Albert Einstein

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Videos

QR-Code	Description
https://www.thorsten-hilker.de/vid/V01Rotation.mp4	Animation of the example in figure 3 shows effect of the entraining force of a turning mass.
https://www.thorsten-hilker.de/vid/V02Translation.mp4	Animation of the example in figure 4 shows effect of the entraining force for a translational movement
https://www.thorsten-hilker.de/vid/V03RotTrans.mp4	Animation shows bounded rotation of two bodies developing by applying entraining force

Table 4: Videos for further illustration of basic concept

QR-Code	Description
http://www.thorsten-hilker.de/vid/V04ErdeMond.mp4	Animation of the example in figure 8 shows how a moon is centered in the turning plane of a planet
https://www.thorsten-hilker.de/vid/V04aPerihelion_wm.mp4	Animation of the example in figure 10 shows how perhihelion of mercury is shifting under influence of the entraining force while eccentricity is decreasing
https://www.thorsten-hilker.de/vid/V06aDifferentialRotation.mp4	Animation drafts the developoment of differential rotation as observed on surfaces of gas-giant-planets
https://www.thorsten-hilker.de/vid/V06bRingplanet.mp4	Animation showing the evolution of a ring around a planet while gathering small particles from distant areas

Table 5: Videos to illustrate effects in planetary scale

QR-Code	Description
https://www.thorsten-hilker.de/vid/V09RotaryDisk.mp4	Animation of the example in figure 11 drafts development of speed within rotary disk

Table 6: Video for further illustration on impact of entraining force towards rotary disk of galaxies

QR-Code	Description
https://www.thorsten-hilker.de/vid/V05RotverschiebungNeu.mp4	Animation of the example in figure 15 drafts the redshift of a photon while passing other particles while the entraing force is applied
https://thorsten-hilker.de/vid/V07LightAccParticles.mp4	Animation shows particles being accelerated by photons due to entraining force
https://thorsten-hilker.de/vid/V07aFilamentsbuildProto.mp4	Animation shows forming of protoplanet from particles in a filament-structure
https://thorsten-hilker.de/vid/V07bFilamentsbuildProtoYY.mp4	Animation shows forming of protoplanet from particles in a filament-structure

Table 7: Videos for further illustration on red-shift