Cooperstock is wrong: The Dark Matter is necessary

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Abstract

"In a series of papers Fred Cooperstock and his collaborators showed that the application of general relativity is sufficient to explain the velocity profile of galaxies. I argue with it."

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Let me explain to you, what are the curvature coordinates (t, r, z, ϕ). They are not comoving coordinates. It is those coordinates, in which the Earth and the galaxy have fixed coordinate values. A stationary observer (those coordinates are kept fixed), does not experience the centrifugal acceleration.

See arXiv:astro-ph/0507619. Take the curvature coordinates, when make the coordinate transformation $\Phi = \phi + \omega(r, z)\, t$, the new coordinates will be co-moving with matter. They will contain following undiagonal terms in metric: $g_{\Phi\, r}$, $g_{\Phi\, z}$, $g_{t\, z}$, $g_{t\, r}$, $g_{z\, r}$, which are time dependent. There is also $g_{\Phi\, t}$ Let us try to make from it the Cooperstock's Eq.(1), hereby so, that comoving feature stays. Also shall stay the axial symmetry. Therefore $f = \Phi + q(r, z)$. Latter does not change the above undiagonal elements, thus one shall transform the time: $T = t\, k(r, z)$. We have 2 unknown functions q and k. Can they eliminate all $g_{\Phi\, r}$, $g_{\Phi\, z}$, $g_{t\, z}$, $g_{t\, r}$? One could investigate it, but it is hardly believable.

But to really get the Eq.(1) the term $g_{\Phi\, t} \approx -N$ could get modified in process. So let us write the modification

$$N = n + X\,,$$

where n comes from centrifugal acceleration of co-movement, the X is from necessary coordinate transformations. The Cooperstock has some thing, which he believed is the star velocity in not comoving coordinates:

$$V = N/r\,.$$

Thus, the real, observable star velocity is

$$U = n/r = V - \frac{X}{r}\,.$$

If the Cooperstock were right, we have folloving velocity of the star in not-comoving system:

$$N/r\,.$$

Therefore to stay on same orbit in opposite movement one shall have velocity in comoving system

$$Y = 2N/r\,.$$

But I have calculated (see Appendix) in assuption, that $z = 0$ state is stable enough:

$$Y = N_r\,.$$

Thus, the difference between results is the anomalous X!

$$X/r = 2N/r - N_r\,.$$

Thus, the

$$u = N_r - \frac{N}{r}\,.$$

One can come to the same conclusion, but different way. The star has velocity $V = N/r$ in not-comoving coordinates. The star emits test-particle in opposite direction, it found to have $v = N_r$ of velocity. Thus, using the simple rule of velocities, one have, that velocity of test-particle in not-comoving coordinates is $W = v - V$. To find anomaly, which we have called "frame dragging", we compare the velocities of clockwise movement and counterclockwise movement: $X/r = V - W = 2N/r - N_r$. Thus, we have found the same formula.

Let us check. In the $V = const$ state holds roughly $N = b\,r$, thus $u = 0$. That is much less than V, thus, there is no flat platoe in Cooperstock's theory. In the $V \sim r$ regime holds roughly $N = k\,r^2$, thus $u = k\,r$. This corresponds to the linear law near the core of a galaxy.

I. APPENDIX

Take circular orbits of a massive test particles. We have metric (15) in file cooper.pdf. Is taken $w = 0$. Because metric is ϕ, t-independent, then from the use of Killing's vectors we have

$$u_t = E = const\,, \qquad u_\phi = L_z = const.$$

Hopefully, these constants you can get from following equations

$$u_\nu u^\nu = 1\,,$$

$$\frac{dz}{ds} = 0\,, \qquad \frac{d^p\,z}{ds^p} = 0\,,$$

and

$$\frac{dr}{ds} = 0\,, \qquad \frac{d^p\,r}{ds^p} = 0\,.$$

For all $p = 1, 2, \ldots$. The higher derivatives are required because the motion shall be stable.

After that you can find the angular velocity as

$$\Omega = \frac{u^\phi}{u^t}\,.$$

Then extract by Cooperstock's "local transformation" the ω and compare the two angular velocities: $|\omega| + 0$ and $|\omega + \Omega|$. The difference is the Frame Dragging.

Arvutasin ja sain teada, et minu faili viga1.pdf suurus $\Omega = -(N_r)/r$, ja $\omega = N/r^2$. Seega Kaasatõmbe võib tõesti olla väga väike: $\omega - |\Omega + \omega| = 2\omega + \Omega = 2N/r^2 - (N_r)/r$. See on kahe $G^{1/2}$ suuruse vahe, seega see võib olla G^2 suurus. Vaata: $G^2 = G^{1/2} - G^{1/2}$. Tulemus $\Omega = -(N_r)/r$ on saadud eeldusel, et ekvatoriaalne orbiit on stabiilne, s.t. mitte kunagi z ei muutu ja on alati null. Kuid 2012 aasta artiklis on jutt, et on ebasümmeetria $z = 0$ tasandi suhtes, eks? Seega osake muudab oma $z = 0$ seisundi. Kui see poleks nii, siis kehtiks võrrand $2\,N/r^2 - (N_r)/r = 0$ antud täpsusel. Seega $N(r) = k\,r^2$, kus k on konstant. Kiirus on $V = N/r = k\,r$. Järelikult tehtud tulemus kehtib seal, kus on galaktika kese: seal ongi lineaarne sõltuvus $V(r)$, vt. Joonis 1. Kuigi meil on ka võrrand $N_{rr} + N_{zz} = N_r/r$. Selle lahendus kujul $N = k\,r^2\,exp(-z)$ kehtib väikese r juures.