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Testing the general relativistic nature of the Milky Way Rotation Curve with Gaia DR2

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Gaia directly measures the kinematics of the stellar component of the Galaxy with the goal to create the largest, most precise three-dimensional map of the Milky Way (MW).
The very core of the Gaia data analysis and processing involves General Relativity (GR) to guarantee accurate scientific products. Nevertheless, any Galactic model should be developed consistently with the relativistic-compliant kinematics delivered by Gaia. In this respect, I will present the first test for a relativistic Galactic rotation curve (RC) with the Gaia second release (DR2) products (MNRAS, Issue 496, 2, 2020, M.Crosta at al.). Dark Matter (DM) is supposed to reside mostly in the Galactic halo. Both a GR model and a DM-based analogue were fit to the best-ever kinematics, derived exclusively from DR2 data, of a carefully selected homogenous sample of disk stars tracing the axisymmetric part of the Galactic potential.

The relativistic RC results statistically indistinguishable from its state-of-the-art DM-based analogue. This supports the ansatz that a gravitational dragging effect could drive the stellar velocities in the plane of our Galaxy far away from its center and mimic DM. Furthermore, one of Einstein's equations provides the necessary baryonic matter density to close the observed gap with respect to the expected Newtonian velocities. Despite some inadequacies, the simplified GR model has proven also to be quite useful to estimate the (external) radial size of the Galactic bulge and the disc thickness at radial distances R>4 kpc.
These findings push on the fully use of Einstein's theory and state the need to develop more complex relativistic galactic "geometries" that take into account the MW multi-structures in concomitance of the incoming and increasingly accurate Gaia data releases and with other Galactic observations targeting the Galactic center.

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