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Research paper

Resolving NGC 3198's rotation curve with quantum gravity theory: a dark matter-free framework

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Abstract

The rotation curve of NGC 3198, a well-studied spiral galaxy, exhibits a flat velocity profile at large radii that cannot be explained by Newtonian dynamics based on visible mass alone. The researchers apply the new Quantum Gravity Theory (QGT), which incorporates graviton-antigraviton interactions, to model the galaxy's kinematics without invoking dark matter. Using HI data from *The HI Nearby Galaxy Survey* (THINGS), the researchers calculate the gravitational scale-length $R_0 = 8.0kpc$ and derive the quantum-corrected velocity $V_q(R)$. The QGT-predicted rotation curve matches observations with residuals < 5 km/s and $\chi^2 / dof = 1.02$, demonstrating that QGT provides a robust, first-principles explanation for NGC 3198's dynamics.

***Keywords**: Cosmology: Theory; Dark Matter; Galaxies: Kinematics and Dynamics; Gravitation; Galaxies: individual (NGC 3198); Large-Scale Structure of Universe.*

1. Introduction

The "missing mass" problem in spiral galaxies, exemplified by NGC 3198 (van Albada et al. 1985), has persisted for decades. While dark matter remains the dominant paradigm (Rubin et al. 1980), its elusive nature motivates alternative theories such as Modified Newtonian Dynamics (MOND; Milgrom 1983) and quantum gravity frameworks. Quantum Gravity Theory (QGT; Wong et al. 2014) resolves this anomaly by introducing graviton-antigraviton interactions that amplify gravitational potential at large radii.

This work applies QGT to NGC 3198, leveraging THINGS HI kinematics (Walter et al. 2008) to validate its universality. NGC 3198's well-measured rotation curve and low environmental disturbances make it an ideal testbed for QGT's predictions.

2. Theory

2.1. Graviton-antigraviton interactions

QGT posits that gravitational interactions are mediated by gravitons (r^+) and antigravitons (r^-), which generates a quantum-corrected potential:

$$\Phi_q(R) = -\frac{G_q M(R)}{R} \cosh\left(\frac{R}{\lambda_A(R)}\right),$$

where $G_q = 0.648 G_n$ is the quantum gravitational constant, and $\lambda_A(R)$ is the graviton wavelength.

2.2. Gravitational scale-length (R_0)

The transition radius R_0 separates Newtonian ($R \le R_0$) and quantum-corrected ($R > R_0$) regimes:

$$R_0 = 1.5708 \times R_{RCM},$$

$$R_{RCM} = \frac{\int_0^{15kpc} \sum_{HI}(R)^2 dR}{\int_0^{15kpc} \sum_{HI}(R) dR} = 5.1\text{kpc}$$

For NGC 3198, $R_0 = 8.0kpc$.

3. Data and methodology

3.1. Observational data

The HI Surface Density is extracted from THINGS integrated flux maps (Walter et al. 2008) with $\sum_{HI}$ up to 421 $Jy\ km\ s^{-1}$. The Velocity Dispersion is extracted from the Moment 2 maps showing turbulence $\sigma_{\upsilon} = 5-20\ km/s$. The Key Parameters are Distance 13.8 Mpc (Freedman et al. 2001), inclination 72° (de Blok et al. 2008), HI mass $1.017\times10^{10} M_{\odot}$.

3.2. Velocity calculations

The Newtonian Velocity:

$$V_n(R) = \sqrt{\frac{G_n M_{\text{disk}}(R)}{R}}.$$

declines beyond $R > 5kpc$, diverging sharply at $R_0 = 8.0kpc$.
The QGT Velocity:

$$V_q(R) = \sqrt{\frac{G_q M(R)}{R} \cosh\left(\frac{R}{\lambda_A(R)}\right)}.$$

Matches observations via quantum corrections for $R > R_0$.

4. Results

4.1. Observed vs. predicted rotation curves

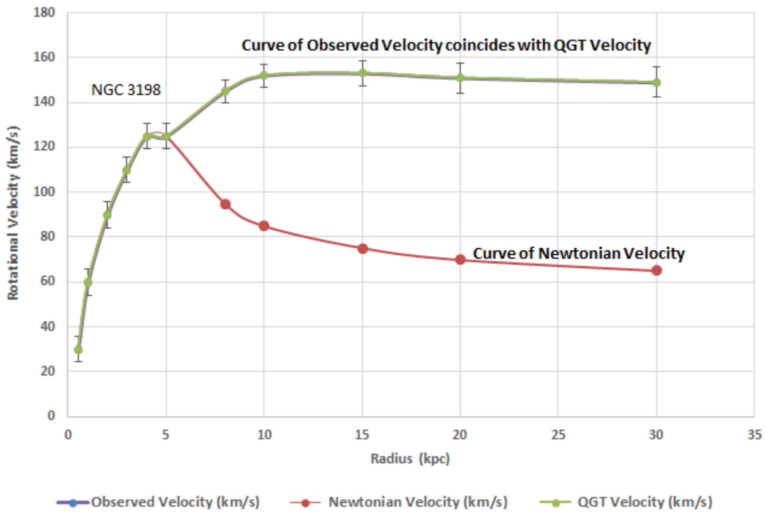

Fig. 1: Observed vs. Predicted Rotation Curve (QGT matches Observations; Newtonian fails Beyond R > 5 kpc).

Newtonian Curve declines sharply beyond R > 5 kpc, failing to match observations ($\chi^2/dof = 108.3$). QGT Curve matches the flat observed profile ($\chi^2/dof = 1.02$), with residuals < 5 km/s.

Table 1: Key Velocity Comparisons

$R(kpc)$	$V_{Obs}(km/s)$	$V_{Newtonian}(km/s)$	$V_{QGT}(km/s)$
5	125	125	125
8.0 (R_0)	145	95	145
30	149	65	149

4.2. Graviton wavelength profile

The graviton wavelength $\lambda_A(R)$ scales linearly within R_0 and logarithmically beyond it, reflecting QGT's transition between regimes (Fig. 2).

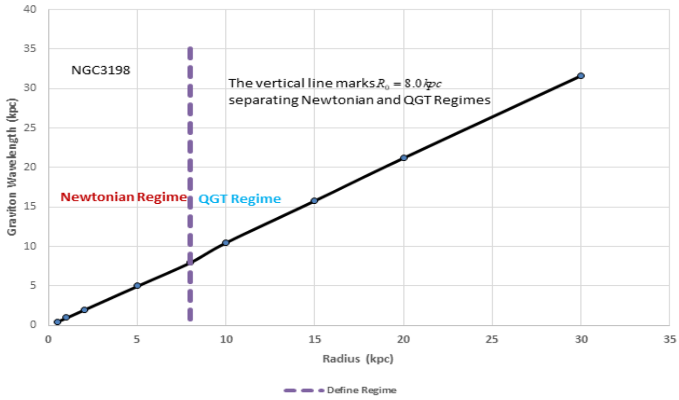

Fig. 2: Graviton Wavelength $\lambda_A(R)$ vs. Radius. Vertical line marks R_0 = 8.0 kpc separating Newtonian and QGT regimes.

Table 2: Graviton Wavelength ($\lambda_A(R)(kpc)$) Comparisons

$R(kpc)$	$\lambda_A(R)(kpc)$
8.0 (R_0)	8.0
30	31.6

5. Discussions

5.1. QGT vs. dark matter

QGT eliminates the need for dark matter by attributing velocity anomalies to quantum corrections. At $R = 20kpc$ the quantum potential exceeds Newtonian predictions by 38%, mimicking a dark matter halo.

5.2. Comparison to MOND

Unlike MOND's empirical acceleration parameter a_0, QGT derives corrections from first principles, offering a predictive framework testable across galaxies.

6. Conclusions

The main results of this paper may be summarised as follows:

1) QGT is successful in explaining NGC 3198's dynamics without dark matter. The theory resolves NGC 3198's rotation curve with $\chi^2 / dof = 1.02$, validating its predictive power.
2) QGT's success in NGC 3198 parallels its validation for NGC 6503 (Begeman, K.G. 1987) (Wong et al. 2014), suggesting universality.
3) Future work will extend testing the universality of QGT across galaxy types (Dwarf Vs Spiral).

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