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The Unified Electro-Gravity Theory to Model Flat Rotation Curves of Spiral Galaxies without Dark Matter

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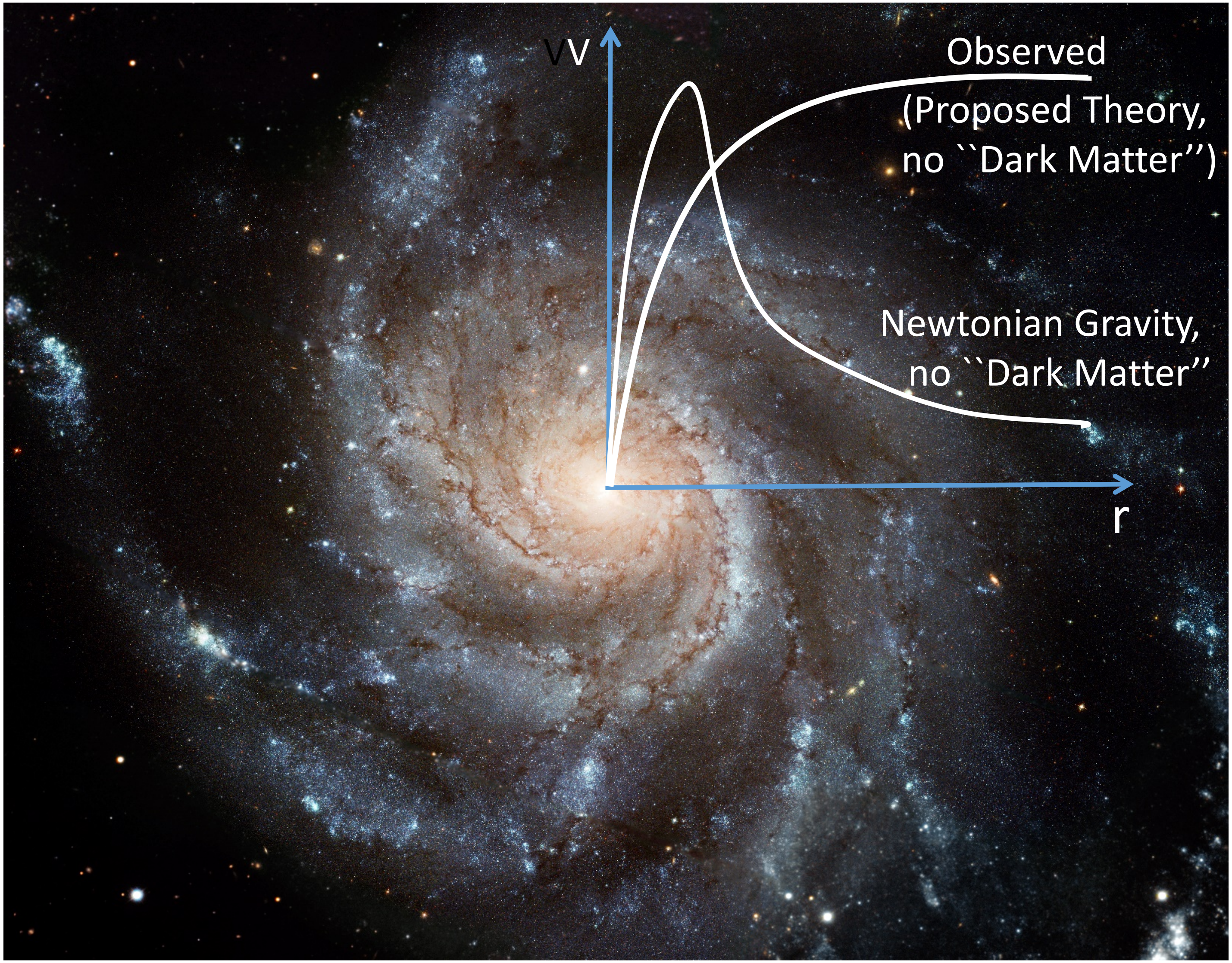
Introduction: Flat Rotation in Spiral Galaxies



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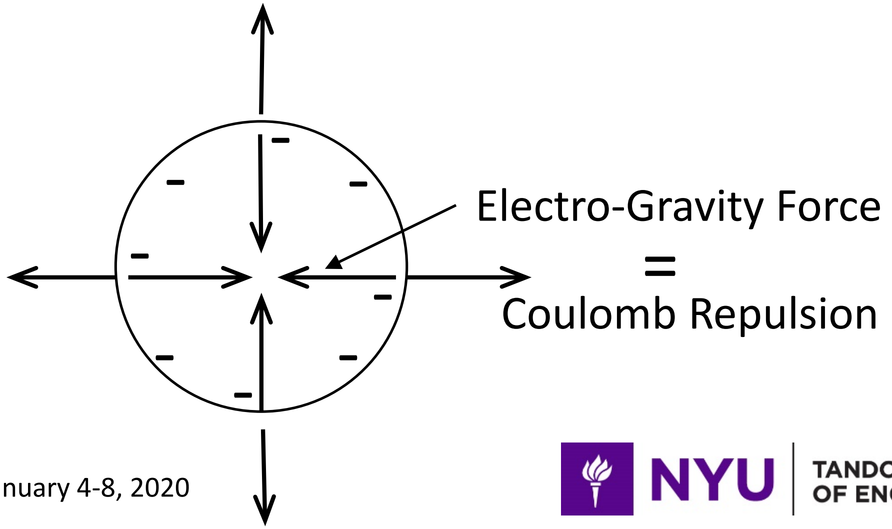
Outline of Talk

- Basic Principles of a new modified gravity theory, called a Unified Electro-Gravity (UEG) Theory, in the presence of electromagnetic fields or light radiation.
- UEG theory for a spiral galaxy: Model flat rotation and predict the Tully-Fisher Relation.
- Validation of a UEG parameter from galaxy survey and for an individual galaxy – NGC2403.
- Conclusion

Unified Electro-Gravity Theory

- Newtonian gravitation is strictly valid only in the external region of a neutral, non-radiating, massive body. The Newtonian gravitation is only a residual effect of strong gravitation in the internal charged structure of the neutral body.
- Gravitation is much stronger in the presence of any electromagnetic field or light radiation, constituting a Unified Electro-Gravity (UEG) field.
- The UEG field of a charged elementary particle, such as the electron, would counter the self-repulsive force of the charge, resulting in a self-consistently stable charge structure.



Unified Electro-Gravity Theory (Continued)

- In the simplest form, for a spherically symmetric structure, the gravitational acceleration $\bar{E}_g$ at a given location due to the UEG field is defined proportional to the electromagnetic energy density W_τ at the location, with the constant of proportionality γ called the UEG constant, and the $\bar{E}_g$ is directed towards the gravitational center.
- The UEG constant is estimated from particle modeling to be approximately equal to $\gamma \approx 6 \times 10^2 (\frac{ms^{-2}}{Jm^{-3}})$, and can be directly related to the dimensionless Fine-Structure Constant $\propto$ of electro-dynamics, in terms of the mass m_e and classical radius r_e of the electron: $(\gamma m_e / r_e^2)$=(2/ $\propto$). (available in N. Das, preprints.org: 2019)

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Unified Electro-Gravity (UEG) Theory for Spiral Galaxies

- The UEG theory must also be similarly applied to support central acceleration in spiral galaxies, with the UEG field produced due to the energy density associated with stellar light radiation.
- For a spiral galaxy, the UEG theory needs to be applied in somewhat different manner, in order to properly account for its spherical asymmetry.
- The proper radial dependence of the UEG field, required to support the flat-rotation curve, is achieved by using an effective energy density $W_{\tau e}$ of radiation for the non-spherical (cylindrical) structure of the galaxy.

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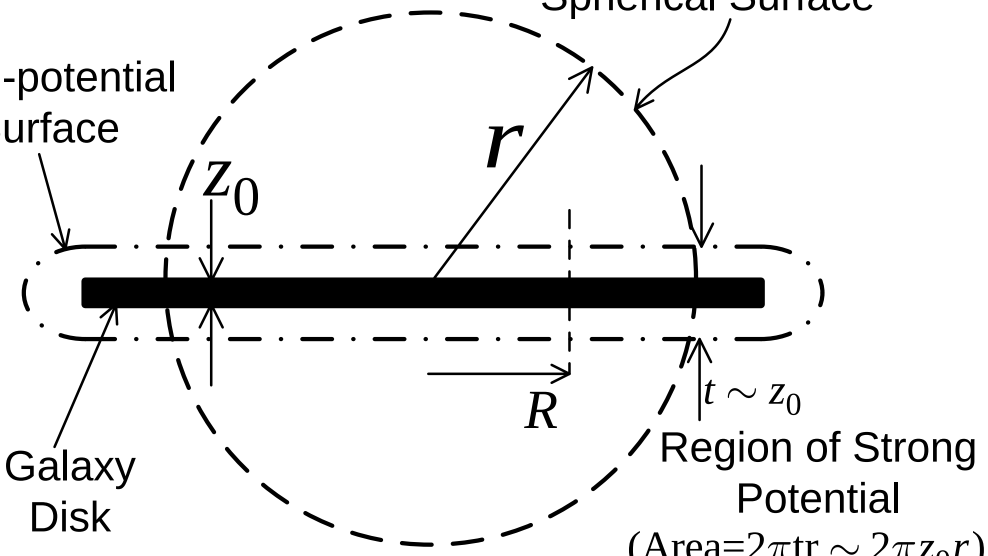
UEG Modeling of Spiral Galaxies



$$W_{\tau e} \times (\sim 2\pi z_0 r) = W_\tau \times (4\pi r^2) = \frac{L}{c};\ r > R$$

$$W_{\tau e} \sim \frac{1}{r},\ W_\tau \sim \frac{1}{r^2};\ r > R$$

$$\text{UEG Acceleration} = \frac{v^2}{r} = \gamma W_{\tau e} \sim \frac{1}{r},\ v = \text{constant};\ r > R$$

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The UEG Modeling of Spiral Galaxies

$$\mu(r)=\mu_0 e^{-(r/R)},\ L=\int_{r=0}^{\infty}\mu(r)\times 2\pi r dr = 2\pi\mu_0 R^2$$

$$W_\tau=\frac{L}{4\pi r^2 c}=\frac{\mu_0 R^2}{2r^2 c}=\frac{\mu_0}{2c}(\frac{R}{r})^2=W_\tau(r=R)(\frac{R}{r})^2,\ W_\tau(r=R)=\frac{\mu_0}{2c}=\frac{\mu(r=R)\times e}{2c}$$

$$W_{\tau e}(r)=W_{\tau e}(r=R)(\frac{R}{r})=W_\tau(r=R)(\frac{R}{r})=\frac{\mu_e(r)\times e}{2c},\ \mu_e(r)=\frac{a}{r}=\frac{\mu_0}{e}(\frac{R}{r})$$

$$\text{UEG Acceleration}=\gamma W_{\tau e}(r)=\frac{v^2}{r}=\frac{\gamma\mu_0 R}{2cr},\ v^2=\frac{\gamma\mu_0 R}{2c}=\frac{\gamma L}{4\pi c R}=\text{constant},\ r>R$$

$$L=\frac{2\pi}{\mu_0}\mu_0^2 R^2=\frac{2\pi}{\mu_0}(\frac{2cv^2}{\gamma})^2\propto v^4;\ \mu_0\sim\text{constant (Tully-Fisher Relation, MOND)}$$

Refinement for general μ_0: $W_{\tau e}(r)=\frac{\mu_e(r)\times e}{2c}\sim\frac{R}{z_0},\ \mu_e(r)=\frac{a}{r}=\alpha_t\frac{\mu_0}{e}(\frac{R}{r}),\ \alpha_t\sim\frac{R}{z_0}$

$$L=\frac{2\pi}{\mu_0}\mu_0^2 R^2=\frac{2\pi}{\mu_0}(\frac{2cv^2}{\alpha_t\gamma})^2\propto v^4;\ \mu_0\alpha_t^2\sim\text{constant},\ v^2\sim\alpha_t\mu_0 R\sim z_0\ \text{(Bizyaev \&, ApJ (2004))}$$

UEG Constant Estimation from Spiral Galaxy Survey

- Galaxy survey from S. Courteau, et al., Astrophysical Journal, 671, 203 (2007)

  - I-Band data, central data point:

    Luminosity $\mathrm{L} = 10^{10.4} L_0 = 3.828 \times 10^{36.4}$ W

    Flat rotation speed $\mathrm{v} = 10^{5.2}$ m/s

    Radius R = $10^{0.5}$kpc=$10^{0.5} \times 3.086 \times 10^{10}$m

    UEG constant estimate $\boldsymbol{\gamma_I = \frac{4\pi R v^2 c}{L}}$**=0.96**$\times \mathbf{10^3}$ $\boldsymbol{(ms^{-2})/(Jm^{-3})}$

  - K-Band data, central data point:

    Luminosity $\mathrm{L} = 10^{10.8} L_0 = 3.828 \times 10^{36.8}$ W

    Flat rotation speed $\mathrm{v} = 10^{5.2}$ m/s

    Radius R = $10^{0.6}/1.678$ kpc=$10^{0.6} \times 3.086 \times 10^{10}/1.678$ m

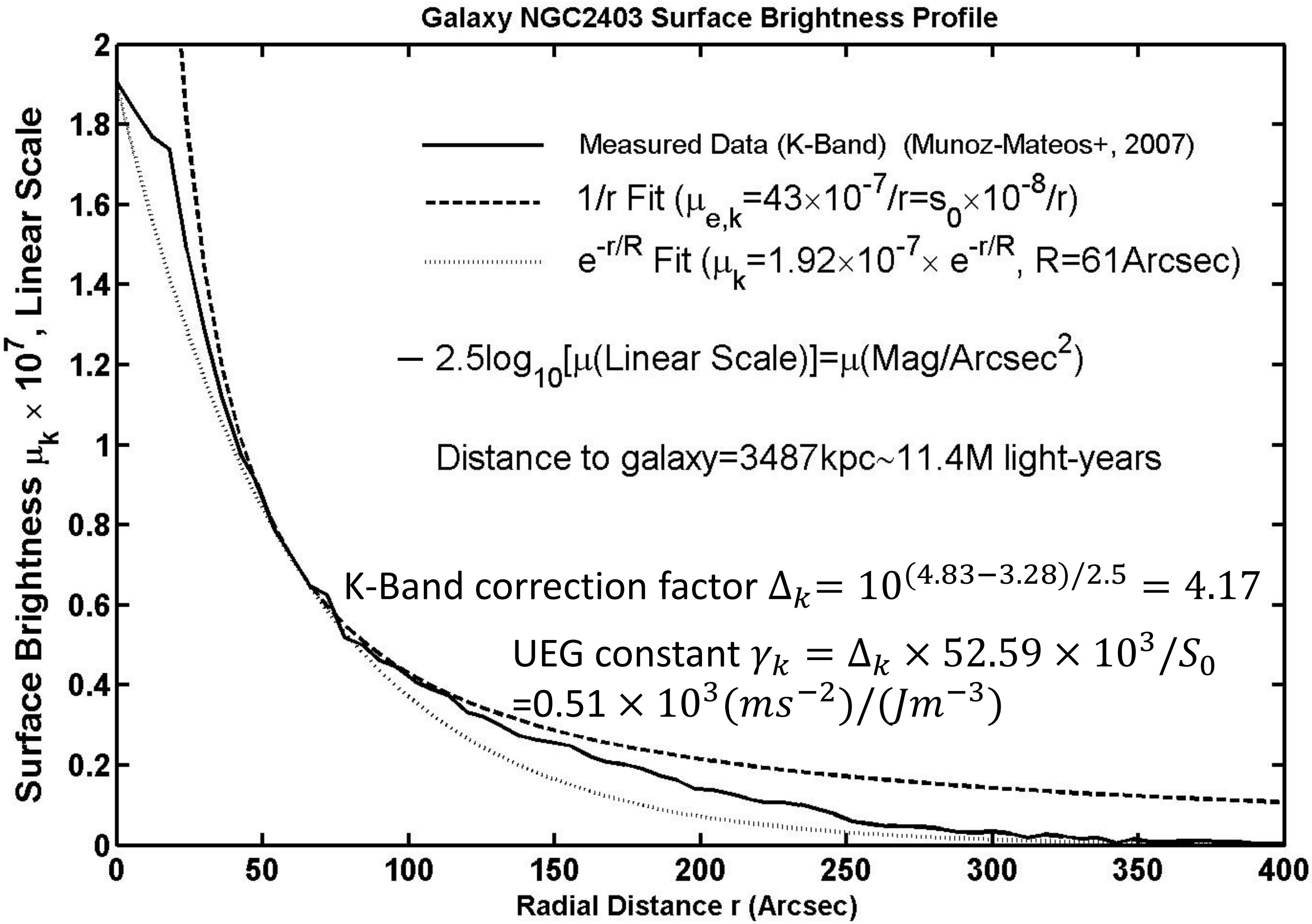
    UEG constant estimate $\boldsymbol{\gamma_K = \frac{4\pi R v^2 c}{L}}$**=0.29**$\times \mathbf{10^3}$ $\boldsymbol{(ms^{-2})/(Jm^{-3})}$

- K-Band data overestimates luminosity, therefore underestimates the UEG constant. I-Band data underestimates luminosity, therefore overestimates the UEG constant.

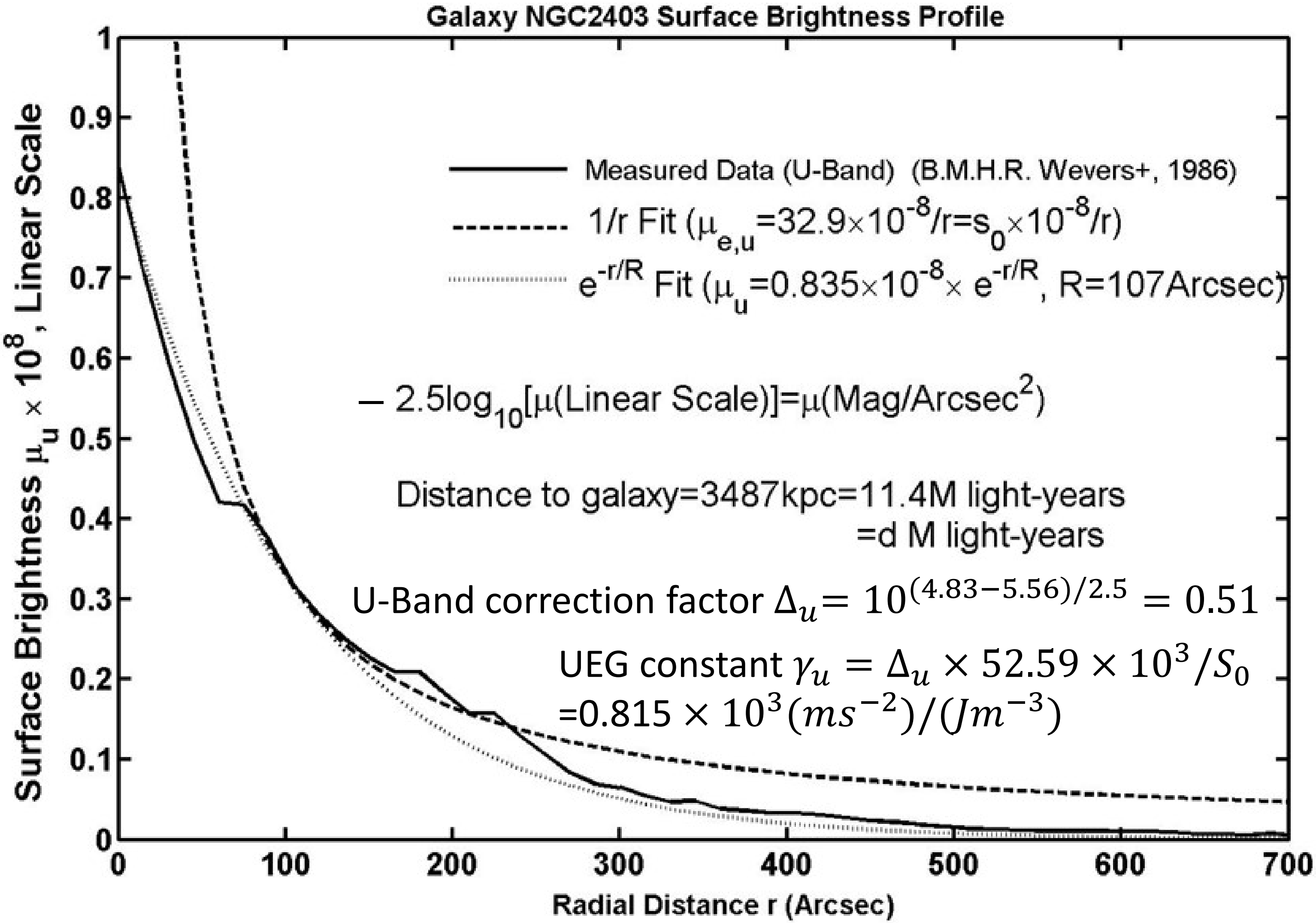
UEG constant estimate $\boldsymbol{\gamma \approx (\gamma_K + \gamma_I)/2}$**=0.63**$\times \mathbf{10^3}$ $\boldsymbol{(ms^{-2})/(Jm^{-3})}$

UEG constant estimate from particle model/electrodynamics $\boldsymbol{\gamma}$**=0.6** $\times \mathbf{10^3}$ $\boldsymbol{(ms^{-2})/(Jm^{-3})}$

The UEG Constant from Specific Galaxy Data



The UEG Constant from Specific Galaxy Data



U-Band correction factor $\Delta_u = 10^{(4.83-5.56)/2.5} = 0.51$

UEG constant $\gamma_u = \Delta_u \times 52.59 \times 10^3 / S_0$
$= 0.815 \times 10^3 (ms^{-2})/(Jm^{-3})$

UEG Constant Estimation from Spiral Galaxy NGC2403 Data

- NGC 2403 U-Band Galaxy data from B. M. H. R. Weavers, et al., Astronomy and Astrophysics Supplement Series, 66, 505 (1986); K-Band data from J. Munoz-Mateos, et al., Astrophysical Journal 658, 1005 (2007

Surface brightness $\mu = \mu_0 e^{-r/R}$

Effective surface brightness $\mu_e = a/r = S_0 \times 10^{-8}/r$ (in Linear Mag/Arcsec^2 , r in Arcsec)

$= S_0 \times 10^{-8} \times (1.46 \times 10^4)/r$ (in W/m^2 ; r in Arcsec)

$= S_0 \times 10^{-8} \times (1.46 \times 10^4) \times (d \times 4.6 \times 10^{16})/r$ (in W/m^2 , r in m, distance to galaxy d in MLY)

Energy density $W_{\tau e} = (e/2)\mu_e/c = 3.04 \times S_0 \times d \times 10^4/\text{r}$ (J/m^3), d in MLY

UEG acceleration $\gamma W_{\tau e} = v^2/\text{r}$

UEG constant estimate $\gamma = \frac{v^2 \times 10^2}{S_0 \times d \times 3.04}$ $(ms^{-2})/(Jm^{-3})$, d in MLY, v in km/s

$= \frac{52.59 \times 10^3}{S_0}$ $(ms^{-2})/(Jm^{-3})$ for NGC 2403;

d =11.4 MLY (Cepheid measurement), v =135 km/s

- K-Band: Surface brightness data $S_0 = 430$, K-Band correction factor $\Delta_k = 10^{(4.83-3.28)/2.5} = 4.17$

UEG constant estimate $\boldsymbol{\gamma_k = \frac{\Delta_k \times 52.59 \times 10^3}{S_0}}$ **=0.51**$\boldsymbol{\times 10^3 \ (ms^{-2})/(Jm^{-3})}$

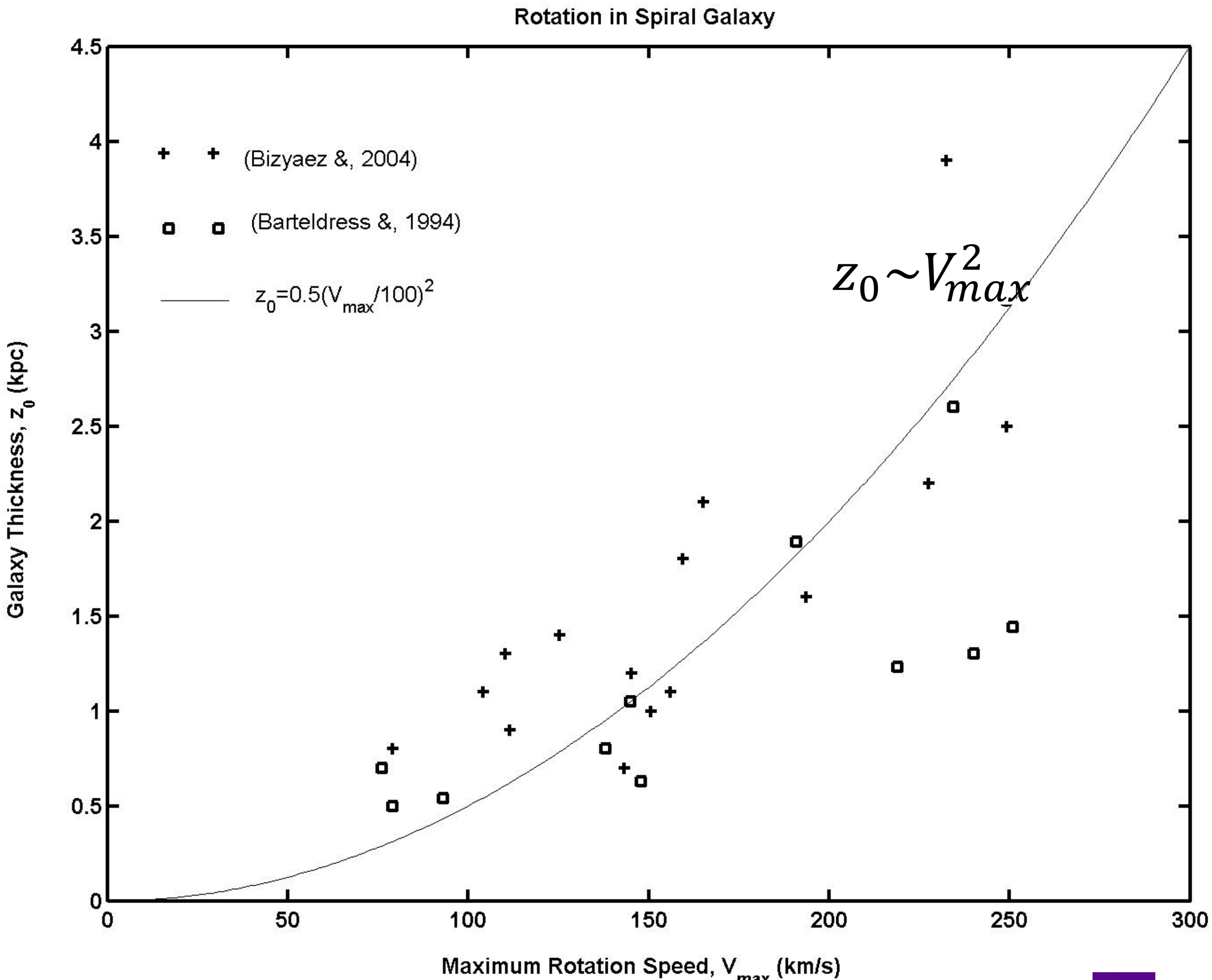
- U-Band: Surface brightness data $S_0 = 32.9$, U-Band correction factor $\Delta_u = 10^{(4.83-5.56)/2.5} = 0.51$

UEG constant estimate $\boldsymbol{\gamma_u = \frac{\Delta_u \times 52.59 \times 10^3}{S_0}}$ **=0.815**$\boldsymbol{\times 10^3 \ (ms^{-2})/(Jm^{-3})}$

- **UEG constant estimate** $\boldsymbol{\gamma \approx (\gamma_K + \gamma_u)/2}$**=0.66**$\boldsymbol{\times 10^3 \ (ms^{-2})/(Jm^{-3})}$

UEG constant estimate from particle model /electrodynamics $\boldsymbol{\gamma}$**=0.6** $\boldsymbol{\times 10^3 \ (ms^{-2})/(Jm^{-3})}$

Flat Rotation Speed to Galaxy Thickness Relation



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Unified Electro-Gravity (UEG) Theory for Spiral Galaxies: Conclusion

- The UEG theory for spiral galaxies successfully predicts the flat rotation curves.
- The UEG constant γ extracted from galaxy-survey and individual galaxies is close to the $\gamma = 0.6 \times 10^3 (\frac{m}{s^2})/(\frac{J}{m^3})$ extracted from a charge-particle model.
- The UEG model predicts the Tully-Fisher Relation (TFR) $L \sim v^4$, consistent with Modified Newtonian Dynamics (MOND) theory, and with observed trend of galaxy thickness $z_0 \sim v^2$ (from Bizyaev &, ApJ (2004)).
- The UEG theory can also be similarly extended as a substitute for dark matter in galaxy clusters and in cosmology (due to CMB radiation, current or future star light)