Empirical Laws of Galactic Rotation

- Flat rotation curves (Rubin-Bosma Law)

  Rotation curves tend asymptotically towards a constant rotation velocity that persists to indefinitely large radii: $V(R \to \infty) \to V_f$

- Tully-Fisher relation (Luminous, Stellar Mass, and Baryonic TF relations)

  The baryonic mass of galaxies scales as the fourth power of the flat rotation velocity: $M_b = AV_f^4$

- Rotation curve shape varies with luminosity (Persic-Salucci "universal rotation curve")

  The shape of rotation curves varies systematically with luminosity, declining mildly at high L and rising slowly at low L: $V(R) = F(L, R_d)$

- Central density relation (lower surface brightness galaxies exhibit larger mass discrepancies)

  The central dynamical surface densities of galaxies is related to their central surface brightnesses: $\Sigma_{dyn}(R \to 0) = f[\Sigma_*(R \to 0)]$

- Renzo's rule (Sancisi's Law)

  "For any feature in the luminosity profile there is a corresponding feature in the rotation curve and vice versa." (Sancisi 2004).

- Radial acceleration relation (Milgrom's Law)

  The observed centripetal acceleration is related to that predicted by the observed distribution of baryons:

$$g_{obs} = \mathcal{F}(g_{bar})$$

$$g_{bar} = \frac{V_{bar}^2}{R} = -\frac{\partial \Phi_{bar}}{\partial R}$$