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Abundance matching, galaxy sizes, and the Tully-Fisher relation in EAGLE

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The Tully-Fisher relation (TFR) has been interpreted as reflecting the mass-velocity scaling (M ∝ V^3) of dark matter halos, but this interpretation has been called into question by abundance-matching (AM) models. We study the TFR of luminous spirals and its relation to AM using the EAGLE set of ΛCDM cosmological simulations. Matching both relations requires disk sizes to satisfy constraints given by the concentration of halos and their response to galaxy assembly. EAGLE galaxies approximately match these constraints and show a tight mass-velocity scaling that compares favourably with the observed TFR. The TFR is degenerate to changes in galaxy formation efficiency and the mass-size relation; simulations that fail to match the galaxy stellar mass function may fit the observed TFR if galaxies follow a different mass-size relation. The small scatter in the simulated TFR results because, at fixed halo mass, galaxy mass and rotation speed correlate strongly, scattering galaxies along the main relation. EAGLE galaxies evolve with lookback time following approximately the prescriptions of AM models and the observed mass-size relation of bright spirals, leading to a weak TFR evolution consistent with observation out to z=1.

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