Too Big to Fail Problem

As early as 1970s scientists started to notice anomalously large gaps between masses (luminosity) of the first most massive galaxies in groups and clusters. (Sandage and Hardy (1973) Dressler (1978a))

The overall luminosity (mass) function of galaxies fits well to the Schechter (1976) function.

Conducting random picking from this distribution scientists obtained synthetic galaxy groups and clusters and compare them with observations. Comparison shows huge gap, even though total luminosity functions (observed and theoretical) match.

Brightest galaxies (observed) are too massive with varience between groups being less than predicted.

Tremaine and Richstone (1977) invented statistic t_1:

$$t_1 = \frac{\sigma(M_1)}{\langle M_{12} \rangle}$$

, Where $\sigma(M_1)$ – varience of the brightest galaxies, $\langle M_{12} \rangle$ – mean gap between first and second brightest galaxies.

– statistic quantifies both differences.

theory predicts $t_1 > 1$, While observations show $t_1 < 1$

($t_1 = 1{,}3$, 2006 Loh and Strauss) ($t_1 = 0{,}55$, 1977 Tremaine and Richstone)

i.e. intermidiate mass galaxies are missing and the biggest galaxies are too standardised

This is called the "Too Big to Fail" problem.

Modern simulations confirm theoretical results showing

$t_1 = 1{,}17$ (IllustrisTNG, 2018)

$t_1 = 1{,}06$ (EAGLE, 2015)

for randomized galaxy sets

and are consistent with real data for ΛCDM arranged simulations

$t_1 = 0{,}24$ (EAGLE ΛCDM, 2015)

$t_1 = 0{,}31$ (IllustrisTNG ΛCDM, 2018)

$t_1 = 0{,}21$ (Choi et. al., 2017).

Also dark matter only simulations provide evidence the TBTF problem has a gravitational/dynamical origin, since it is stronger in them. It was suggested that "mergers" are the reason. (Ostriker, 1977)