A mid-life crisis of the Universe? A giant red disk galaxy at $z = 0.76$

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Recent observations are discovering more and more galaxies that do not fit in the conventional Hubble classification scheme [1]. Locally, the SDSS survey has discovered a population of massive red spirals (e.g., ref. [2]) with stellar masses above $10^{10.5}$ solar masses. At redshift 1 to 3, a study [3] using the CANDLES survey data found that for massive galaxies with stellar mass $M > 10^{11}$ solar masses, 18% of the quiescent galaxies are disc dominated with specific star formation rates below 10^{-10} per year.

In ref. [4], the authors announced the discovery of a giant red disk galaxy at redshift $z = 0.76$ (when the Universe was roughly half of its current age). This galaxy has an effective radius of about 8.8 kpc, with little star formation and a nearly round shape (its axial ratio is 0.85). Puzzlingly, its surface brightness is well fitted by a Sersic profile with $n = 1.22$, close to the exponential profile, rather than the $n \sim 4$ de Vaulouleurs's profile for ellipticals. The authors argue that the galaxy may be at the center of a massive dark matter halo but has no central black hole. It appears to have similar properties of the passive disk galaxies found in ref. [3]. Ref. [4] suggests that further IFU observations may be useful. But this may be challenging, since if it is indeed a disk galaxy, then it is nearly face-on so its rotation signature may be difficult to measure, thus making it not easy to classify this galaxy kinematically [5]: Is it a fast rotator or a slow one? Is it actually an elliptical with an unusual surface brightness profile?

The discovery of such objects [3,4] raises several important questions. (1) How does the abundance of such massive passive disk galaxies evolve? The authors of ref. [4] suggest to use photometric and spectroscopic survey data to answer this question. In particular, it will be interesting to obtain higher-resolution images (e.g., using HST or adaptive optics) to resolve its central light distribution. (2) How do these galaxies form and evolve? Do they form by mergers which tend to produce low Sersic index objects? Such galaxies appear to be rare in current numerical simulations, which points to some deficiency in their implemented feedback. (3) How is the star formation in such galaxies quenched? Is there a significant amount of gas in their outskirts? In this regard, radio/sub-mm observations of these objects will be informative. Only with more observational data will it be possible to solve the potential crisis raised by this curious object in the mid-life of the Universe.

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