Galaxy Activity in Semi-Analytical Models

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Introduction:

Active galactic nuclei (AGN) feedback is believed to play an important role in shaping a variety of observed galaxy properties, as well as the evolution of their stellar masses and star formation rates. In particular, in the current theoretical paradigm of galaxy formation, AGN feedback is believed to play a crucial role in regulating star formation activity in galaxies residing in relatively massive haloes, at low redshift. In recent years, detailed statistical information on the dependence of galaxy activity on stellar mass, parent halo mass and hierarchy (i.e. centrals or satellites) has become available **[4]**. In this paper **[1]**, we compare the observed fractions of galaxies belonging to different activity classes (star forming, AGN and radio active) with predictions from theoretical models of galaxy formation.

Models:

We consider the predictions of four different, independently developed Semi-Analytical Models of galaxy formation and evolution:

WDL08 [6] **SHC [5]** **KvB [3]** **MORGANA [2]**

All models follow the growth of SMBHs and differentiate between a 'bright-mode' (or 'QSO-mode') and a 'radio-mode' of AGN feedback.

Bright-mode: large accretion rates associated with galaxy mergers, that can destabilize large amounts of cold gas in the colliding galaxies and drive it towards the centre of the merger remnant **=>** responsible for the evolution of the QSO-LF.

Radio-mode: associated with the efficient production of radio jets connected with low accretion rates **=>** important role in quenching cooling flows at the centre of massive clusters.

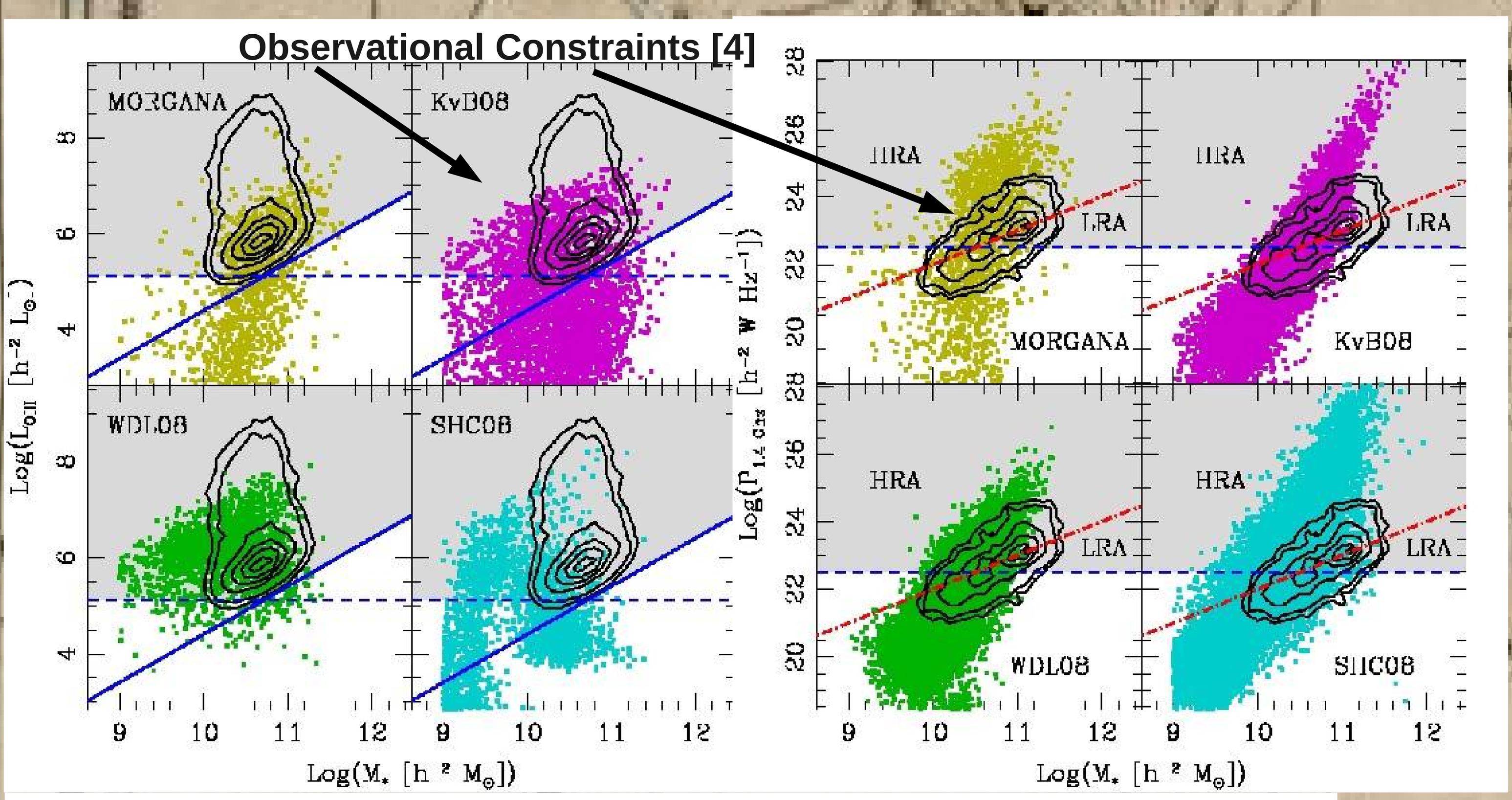

Fig.1: We adopt empirical relations to convert physical properties into observables (O[III] line strength and radio power). Black solid contours refer show the levels of observational data **[4]**.

Results (Fig.2):

(A) Almost all massive centrals are predicted to host a bright radio source, while only a small (few per cent) fraction of galaxies belong to this class in the data.
(B) Radio brightness is expected to depend strongly on the mass of the parent halo mass in the models, while strong (HRA) and weak (LRA) radio galaxies are found in similar environments in data. In most models this result is not surprising, since accretion rates on to BHs during radio-mode are explicitly related to the mass of the parent halo.
(C) MORGANA is the only model that predicts a significant population of low-luminosity radio galaxies for central galaxies in massive haloes (even if both the predicted fractions and the distributions differ from those observed). This is due to the adopted scheme for AGN feedback, which includes a modeling of the cold gas reservoir around the SMBH.
(D) The SHC08 model predicts total fractions of galaxies with AGN activity that are significantly lower than other models. We ascribe this result to the inclusion of a critical mass for BH accretion: since at low redshift most massive galaxies have central SMBHs with masses already larger than their critical mass, further accretion on to these objects is suppressed.
(E) MORGANA predicts larger fractions of SF galaxies, with respect to observations, at high stellar and halo masses. This is due to an inefficient quenching of star formation in massive haloes, related to the adopted AGN feedback scheme**.**

These results are robust against any reasonable change in the assumptions for the conversion from predicted physical quantities into radio luminosities. The disagreement between the predicted and observed fractions of radio sources represents a potentially serious problem for current models of galaxy formation and evolution. If, as suggested by our analysis, we need to assume a weaker dependence on halo mass, then this physical process might not be capable of offsetting the cooling flows alone. This is hinted at by the fact that the model which predicts the lowest fraction of radio sources (MORGANA) is, at the same time, the model which provides the worst agreement with the distribution of SFGs. Our results suggest that either more sophisticated modelling of the triggering of radio activity and its impact on the thermodynamics of the surrounding gas is needed, or other processes are important in preventing the gas in massive haloes from cooling.

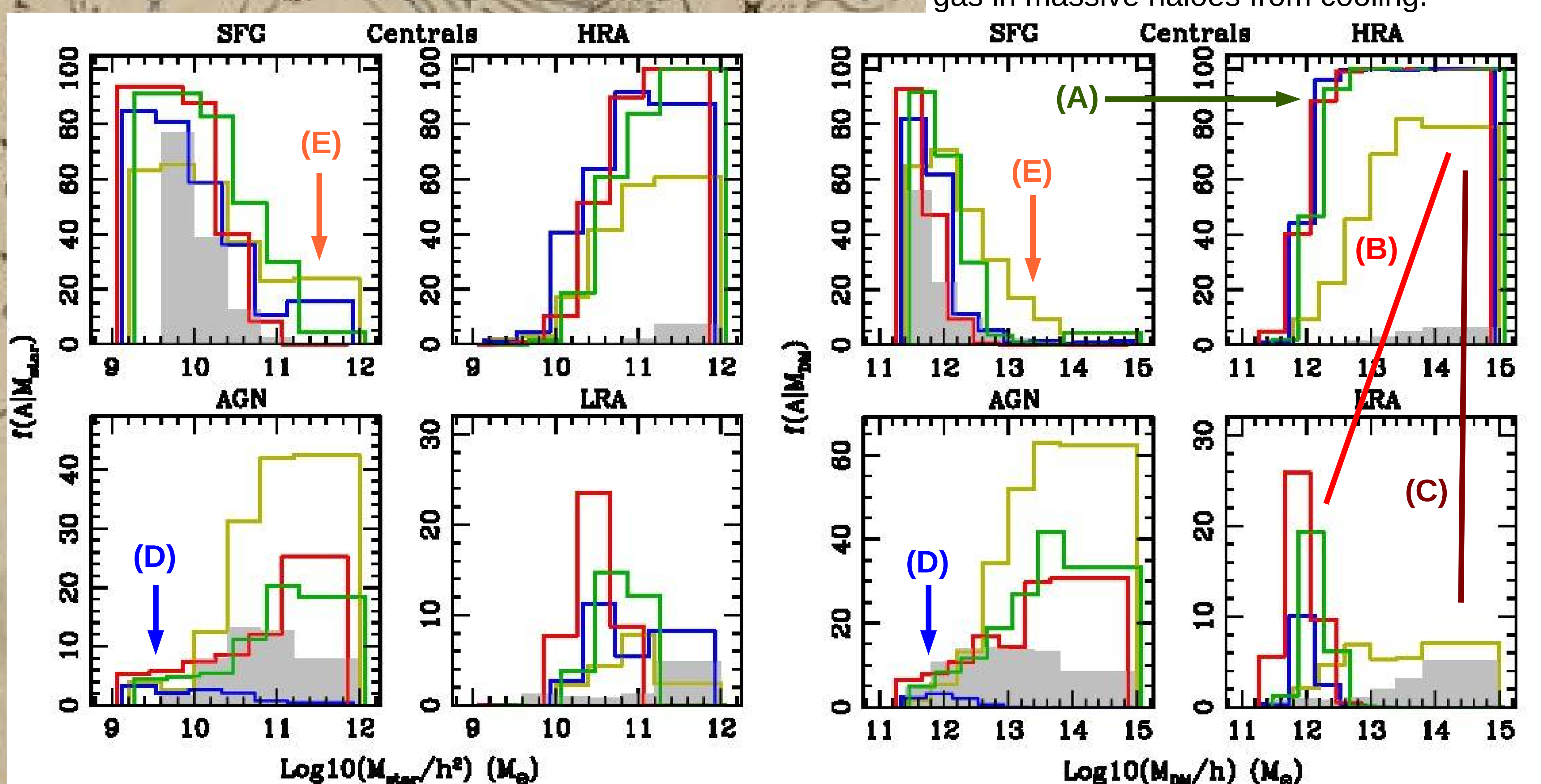

Fig.2: Fraction of central galaxies belonging to different activity classes as a function of stellar mass (right-hand panel) and of the mass of the parent DM halo (left-hand panel). Shaded areas show the observed fractions **[4]**.

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