

1. Introduction

The cosmological evolution of AGN is important for understanding the mechanism of accretion onto supermassive black holes, and the related evolution of the host galaxy. In this work we consider the behaviour of two distinct AGN populations: one unabsorbed (low hydrogen column density) and the other absorbed (high column density and lower Eddington ratio). We follow the evolution of X-ray detected AGN, and compare the final result with the observed local distribution of black holes (BH).

We find that two distinct populations of AGN can evolve with a wider range for Eddington ratio λ and accretion efficiency ϵ than what is usually considered, and still be consistent with the local mass function.

2. Mass Function Estimates

2.1 Model description

The evolution model used is similar to the one used by Marconi et al. 2004 and Shankar et al. 2007, but considering two populations of AGN with different hydrogen column densities:

- Unabsorbed $10^{20} \text{ cm}^{-2} \leq N_H < 10^{22} \text{ cm}^{-2}$
- Absorbed $10^{22} \text{ cm}^{-2} \leq N_H < 10^{24} \text{ cm}^{-2}$

We start from $z = 3$, assume that the total number of BHs is constant with time (no merging), and that their growth is due to mass accretion only.

For the X-ray luminosity function we use the Ueda et al. 2003 luminosity dependent density evolution, and an Eddington ratio dependent bolometric correction (Vasudevan & Fabian 2007). The fraction of absorbed and unabsorbed objects is given by \mathcal{N}_i , integrating the Ueda et al N_H distribution.

In terms of the evolved mass function we get:

$$\frac{d\phi(M,0)}{d \log M} = \mathcal{N}_H(L_X) \left[\frac{(1-\epsilon)\lambda^2 c^2 M}{\epsilon t_E^2} \frac{1}{\kappa(\lambda)} \int_0^3 \frac{\partial}{\partial L_X} \left[\frac{d\phi(L_X, z)}{d \log L_X} \right] \times \left| \frac{dt}{dz} \right| dz + \frac{d\phi(L_X, z_i)}{d \log L_X} \right]$$

2.2 Results

As one can see in Fig. 1, we find a good agreement between the evolved mass function (red curve), and the local one (black curve). The shape of the absorbed and unabsorbed mass functions is different: unabsorbed objects have a steeper distribution, contributing more in the low mass range, while absorbed objects have a flatter mass function, contributing more in the higher masses.

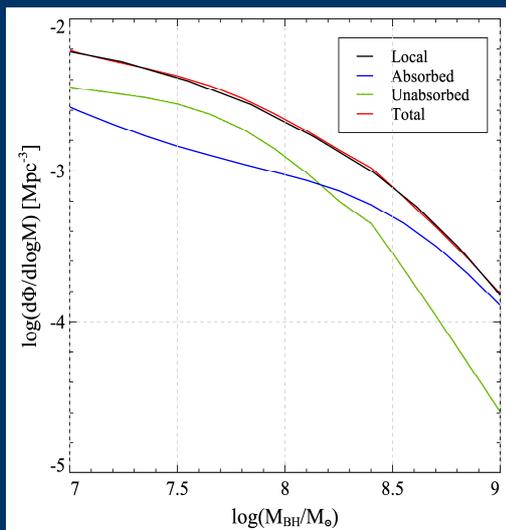


Fig 1: Comparison between the evolved number of AGN per unit volume per logarithm of mass and the local mass function (in black) by Marconi et al. 2004. The red curve is the total population (absorbed plus unabsorbed). The values used were $\lambda_{\text{abs}} = 0.107$, $\epsilon_{\text{abs}} = 0.081$, $\lambda_{\text{un}} = 0.891$, $\epsilon_{\text{un}} = 0.151$.

3. Constraints

To be able to constrain ϵ and λ , we search the parameter space, changing simultaneously the values for accretion efficiency and Eddington ratio for each population, and comparing the evolved mass function with the local one. We then select the values for which there is a good agreement (± 10 per cent) between the two functions.

Following the relation between N_H and Eddington ratio found by Fabian et al. 2008, we assume $\lambda_{\text{abs}} < \lambda_{\text{un}}$.

In Fig. 2, we see that absorbed AGN have low Eddington ratios ($\lambda < 0.3$), while unabsorbed have high Eddington ratios.

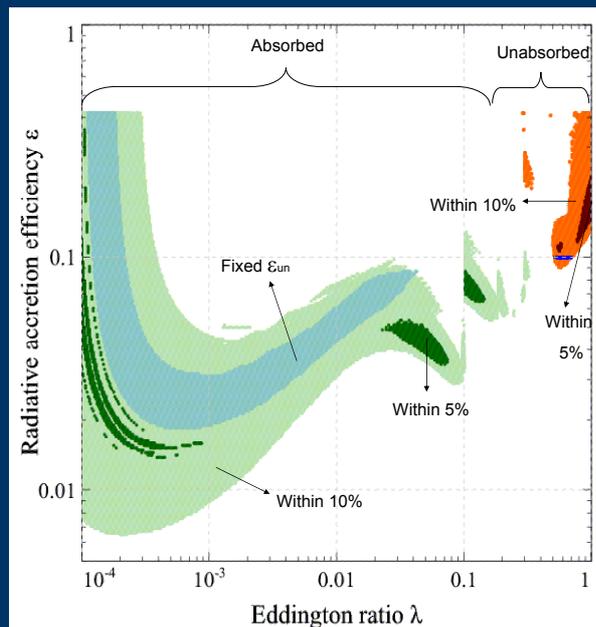


Fig 2: Allowed values for λ and ϵ for absorbed and unabsorbed AGN. Light green and light orange areas represent, respectively, absorbed and unabsorbed objects, within the 10 per cent agreement region, and the darker areas (green – absorbed, brown – unabsorbed), within the 5 per cent of agreement. The light blue points refer to absorbed objects within the 10 per cent error, considering a fixed ϵ_{un} of 0.1 (dark blue horizontal line).

4. Conclusions

- We consider two populations of AGN for the first time and obtain good agreement between local and evolved mass functions
- Eddington ratio and accretion efficiency have an important role in the shape of the evolved mass function
- They can have a wider range than what is usually considered
- We do not find unabsorbed AGN with low λ or absorbed with high λ
- No need for super-Eddington accretion ($\lambda > 1$)
- Absorbed AGN have to be taken into account, they contribute to the high BH mass range
- There can be a transition from absorbed to unabsorbed or vice versa. 'Cycling' scenario?

References:

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