

## Bella e la bestia

# Brutto e' bello

#MeToo

## The beauty of science

Fake news? Fake results? Fake missions? The beauty of black holes (and their host galaxies)

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## Beauty for the physicist

Black holes are described by Kerr's metric as an exact solution of Einstein's equation

The simplest objects: two parameters, mass and spin

## Beauty for the astrophysicist



Sgr A\* a black hole the heart of a galaxy stars gas

## Massive black holes in galaxies

Massive black holes should naturally grow along with galaxies through accretion and MBH-MBH mergers and influence the galaxy through feedback





accretion in low-mass galaxies (Dubois+14; Habouzit+17; Bower+17; Angles-Alcazar+17; Prieto+17; McAlpine+17,18)

Then, black holes catch up with their galaxies







The high-z sample covers a range compatible with z=0 observations, especially considering Eddington's bias (Shields+06;Lauer+07;Volonteri&Stark09)



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Measuring the <u>same</u> quantities in simulations and observations

Simulated galaxies and black holes happily evolve towards the observations



## Feedback: radiation vs jets

Ramses: Grid-based hydro solver with mesh refinement (Teyssier 2002)

Turbulent, inhomogeneous interstellar medium (Wagner & Bicknell 2011) - no cooling, gravity, star formation

Radiation: RAMSES-RT (Rosdahl et al. 2013, Rosdahl & Teyssier 2015)

- moment method to solve radiative transfer in RAMSES
- radiation pressure + diffusion of multi-scattering IR radiation
- reduced speed of light approximation
- AGN SED with 5 photon groups,  $IR \rightarrow UV$  (Bieri+16)
- Jet: hydro source term, cylindrical base, orientation can be chosen
  - steady density/momentum/energy flux
  - $\rho_{jet}$ =0.01  $\rho_{ambient}$
  - straight beam, self-collimated by internal shocks



0.5 Myr

1 Myr

1.5 Myr

5 Myr

Cielo, Bieri, MV+18

### Feedback: radiation vs jets



A mass outflow rate of Mdot<10<sup>4</sup>  $M_{\odot}$ /yr in all cases except max46 and min46 – only in these two cases the gas distribution is affected

### The feeding/feedback cycle



A mass inflow rate of Mdot= 0.01  $M_{\odot}$ /yr corresponds to an AGN power of  $P_{AGN} = \varepsilon$  Mdot c<sup>2</sup> = 5.7 ×10<sup>43</sup> erg/s for  $\varepsilon$  =0.1



Courtesy of Hugo Pfister