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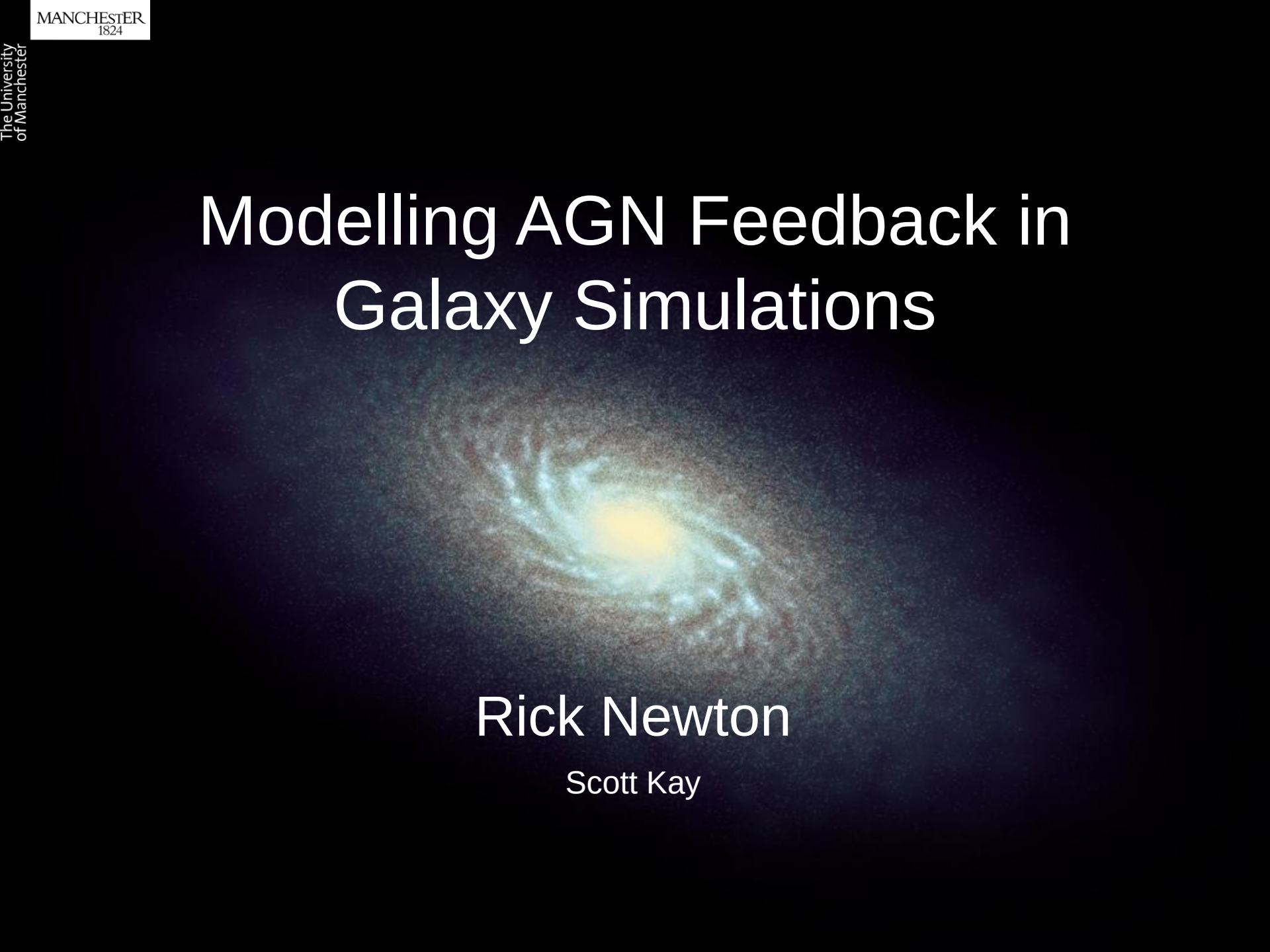
Modelling AGN Feedback in Galaxy Simulations



Rick Newton

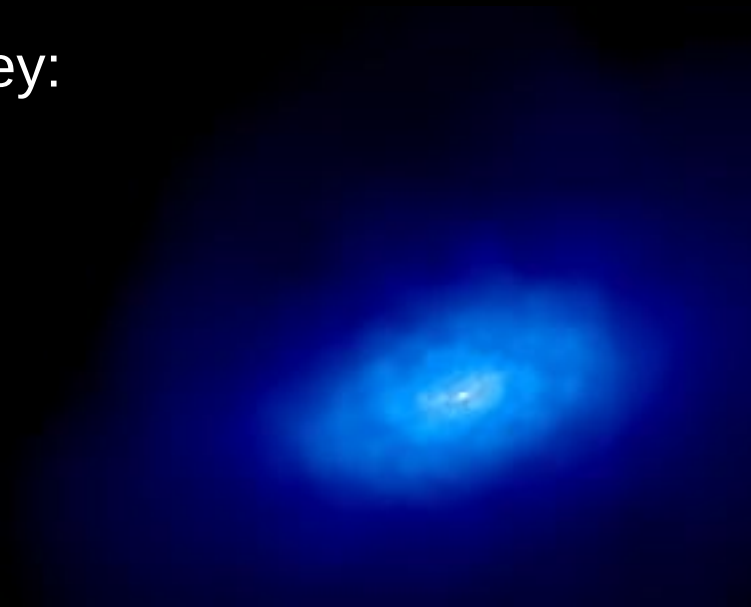
Scott Kay

AGN at a Distance

- Active Galactic Nuclei
- Black holes as a source of energy
  - Due to the effects of heating in-falling material

- ‘Small’ scale physics poorly understood
- Do know they can have a BIG impact on LARGE scales

- In simulations, black hole particle is key:
  - Formation
    - How? where?
  - Growth
    - Accretion rate? Accretion radius?
  - Feedback
    - Thermal/kinetic? Mass loading?

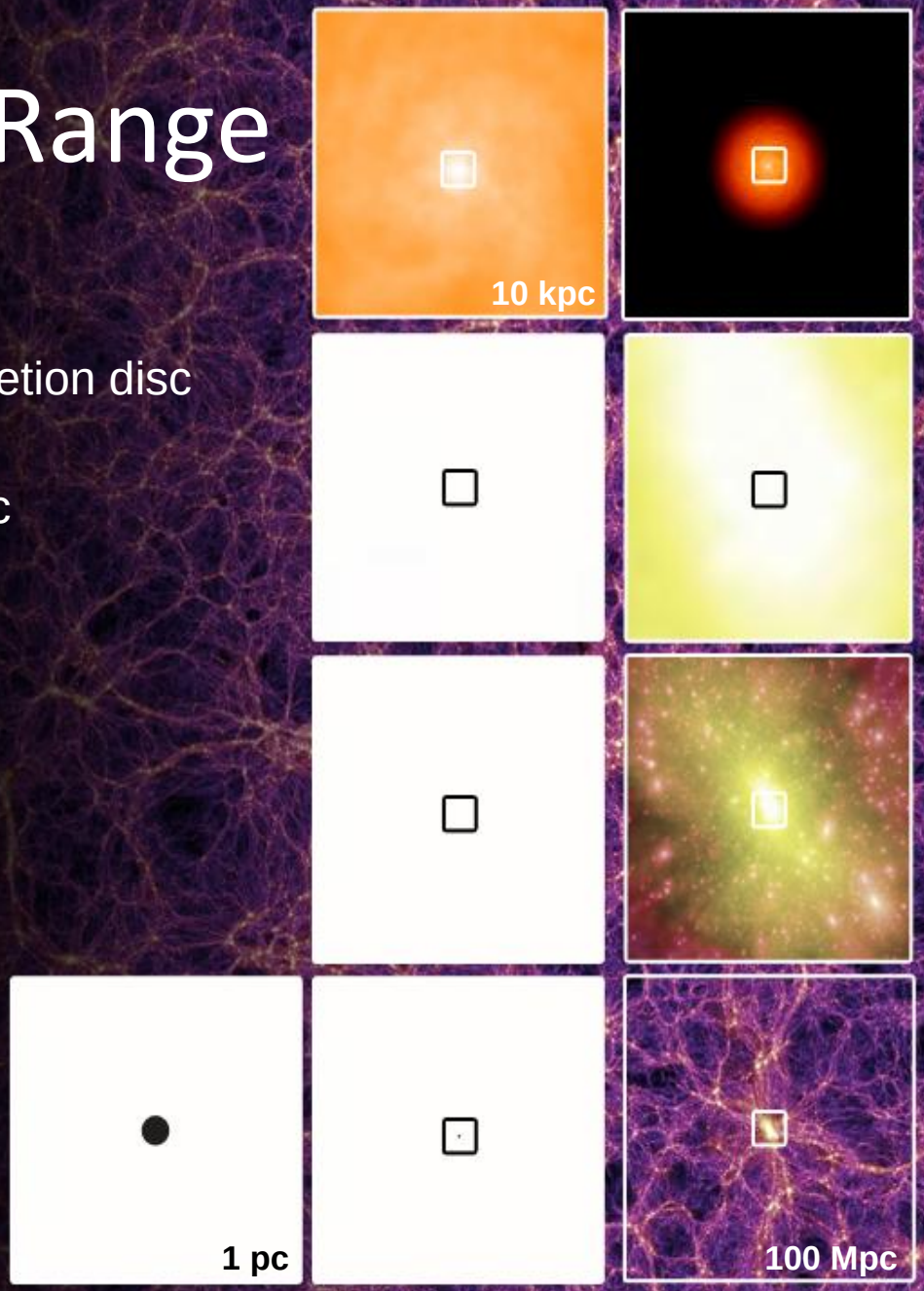


High Dynamic Range

- Spatial range of scales
  - ~Gpc simulation → sub-pc accretion disc
  - 10 orders of magnitude
  - Typically only resolve to ~100pc

- Temporal resolution is critical
  - $\dot{M}_{BH}$ fixed over a timestep
    - Effectively neglects feedback!
  - May attempt to accrete more particles than 'neighbours'
    - New timestep limit

$$\mathrm{d}t_{acc} = k_{acc}\frac{N_{ngb}\,m_{gas}}{\dot{M}_{BH}}$$



Numerical Efficiency

- Communication
  - Nature of parallel codes, no single core knows of all gas
  - Each step in AGN model needs comm.
  - BH thread does not know about all 'local' gas
    - Complicates algorithm design
      - e.g. heat exactly 1 neighbour at random
  - Takes time; minimise and consolidate

- Memory
  - Wish to avoid adding new entries to arrays
    - 3 new 4byte entries in 10 billion part's → 120GB RAM

Ongoing Work

- So far, 3 distinct AGN models employed in modular fashion
- Conduct **first** full investigation disentangling 3 stages of method
- Perform tests in isolated galaxies, mergers and toy groups
  - ...before going on to cosmological volumes...

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The Results