The ABC of Stars and Galaxies

How stars and galaxies are born,
how they live and how they die

Dr Steve Barrett Norton Priory 17 Jan 2024

The ABC of Stars and Galaxies

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2

The ABC of Galaxies

Accretion

Galaxies were formed by matter created in the Big Bang accreting under the influence of gravity

Black Holes

Supermassive black holes are at the centres of galaxies; some are very active, sometime are quiescent

Collisions

Galaxies grow by colliding and merging with other galaxies over billions of years

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3

The ABC of Stars

How do you make a star? Simply follow these **ABC** steps:

Start with a big cloud of hydrogen (made in the Big Bang)

A *Wait …*

B *Wait some more …*

C *Wait a bit longer …*

You're done

You now have a star.

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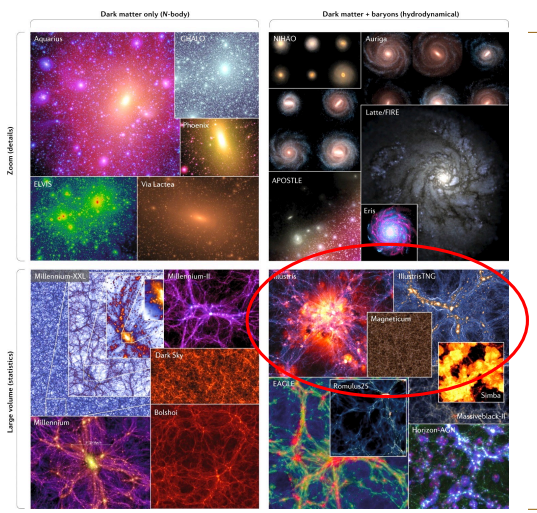
4



Simulations

Everything we understand about the evolution of cosmic-scale structures is the result of computer simulations.

This talk uses images and videos from the 'Illustris' simulations.

5

Cosmic Web

Everything in the observable Universe once existed in a volume the size of a golf ball.

The 'dimples' were small variations in density…

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6

Cosmic Web

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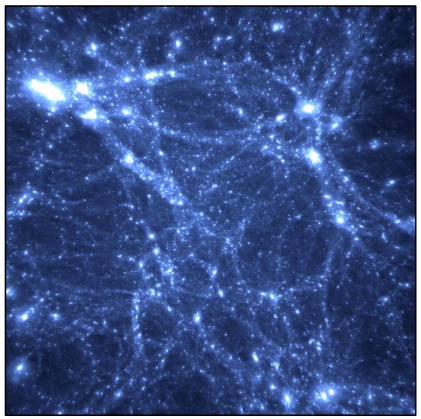
The 'dimples' were small variations in density…

… that over billions of years collapsed into a cosmic web of filaments and voids.



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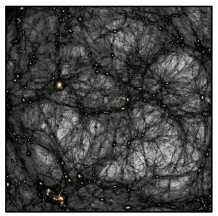
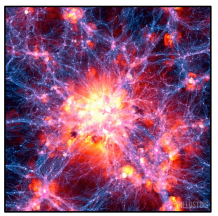
7

Computer Simulations

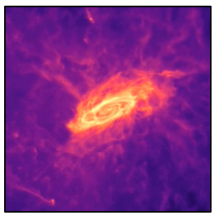
Simulations of galaxy formation and evolution that run from just after the Big Bang to the present day help us understand what happened.



Dark matter web



Black holes + supernovae



Matter accretion

The simulations account for the effects of dark matter, star formation, black holes and supernovae in calculating how matter accumulates over billions of years into galaxies.

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www.illustris-project.org

8

IllustrisTNG
150 kly
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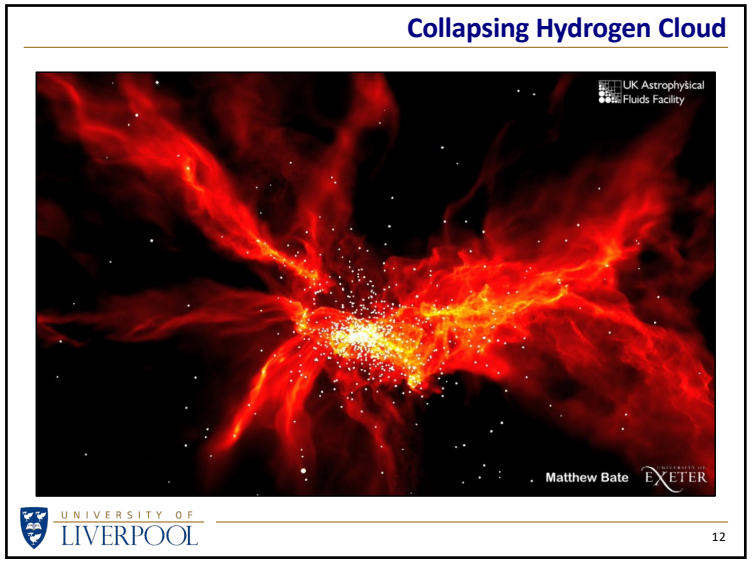
9


Collapsing Hydrogen Cloud
UK Astrophysical Fluids Facility
Matthew Bate
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12

Star Cluster

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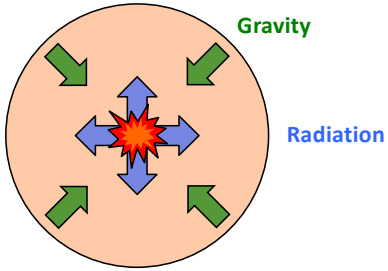
13

A Question of Balance

All stars are a balance between the opposing forces of gravity and radiation pressure.

When the opposing forces are balanced, the star is stable.

When out of balance, the star must evolve.



Many aspects of star birth, life and death can be explained in terms of this balance of opposing forces.

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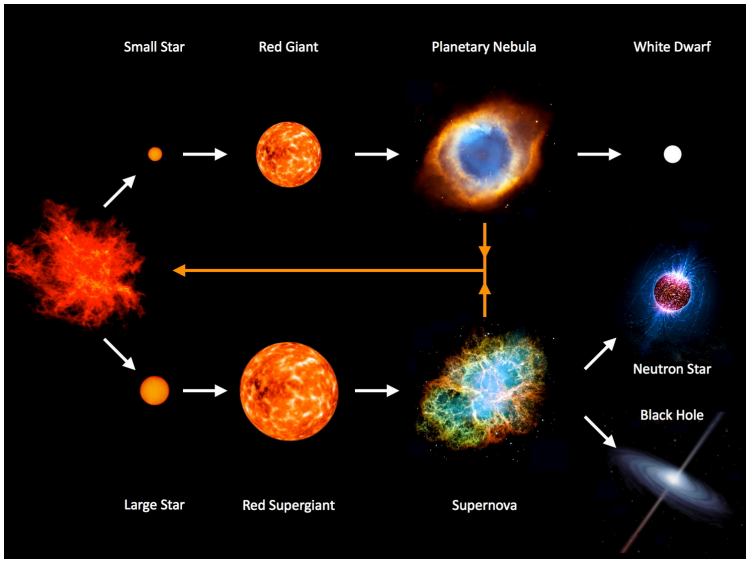

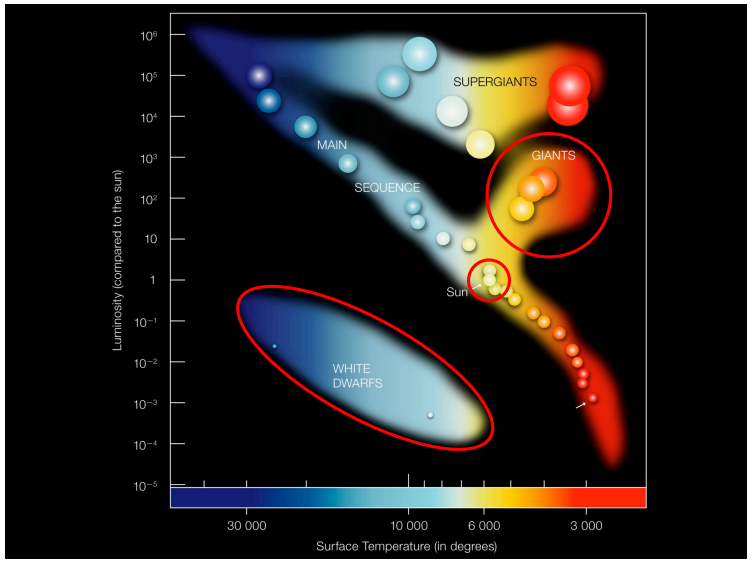

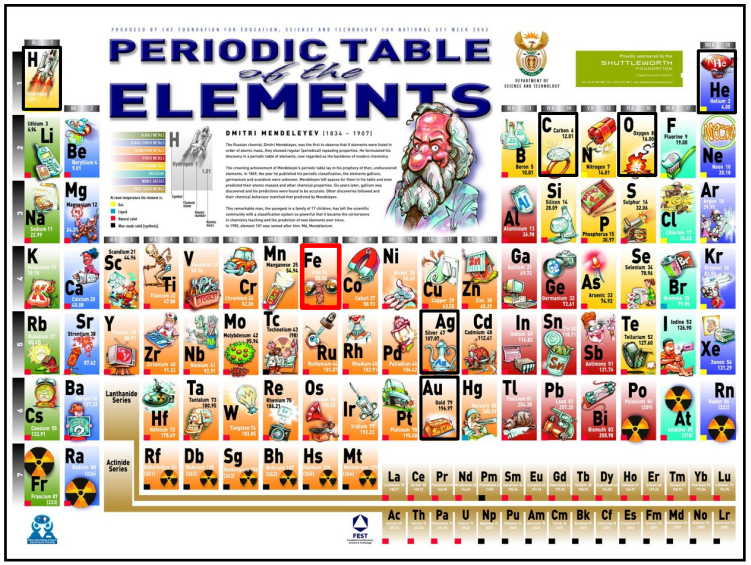

Planetary Nebula

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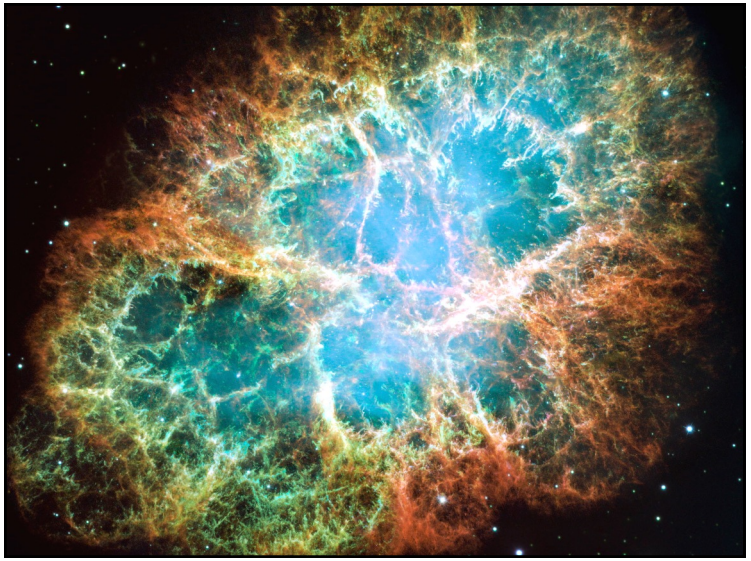
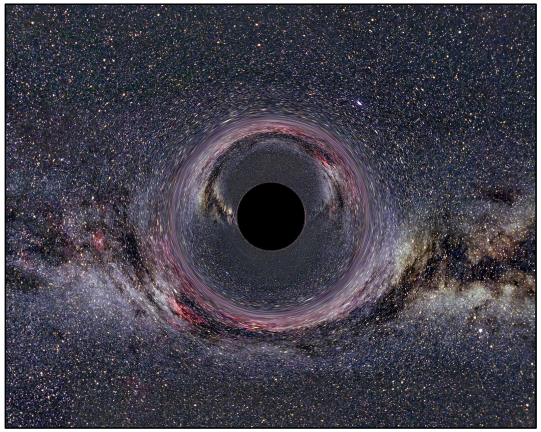
18



Black Hole



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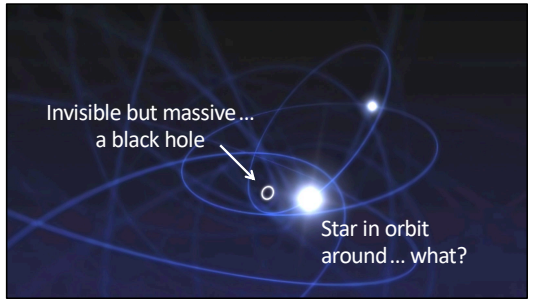
* See "Warping Space and Time"

20

At the Heart of a Galaxy

How do we know what lies at the centre of a galaxy?

A close look at stars orbiting near the centre of the Milky Way tells us that there is something invisible but ***very*** massive lurking there…



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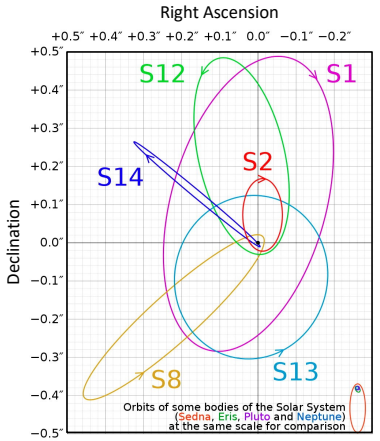
Supermassive Black Hole



By recording star positions over more than a decade, it was calculated that the object keeping these stars in their orbits has a mass of

4 million $M_\odot$

and a size of no more than a few light-hours (≈ orbit of Pluto).

$M_\odot$ = mass of our Sun

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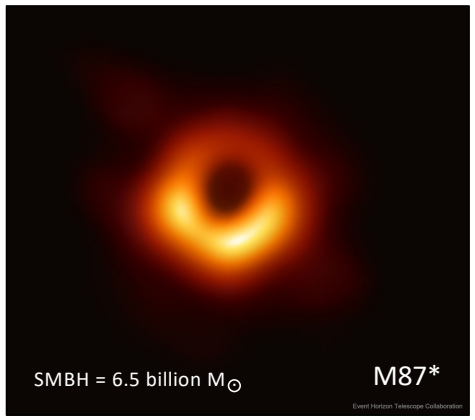
22

Image of SMBH in M87



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Galaxy Snapshot

An image of a galaxy can give the false impression that the structure is essentially static, except for a slow rotation that can take hundreds of millions of years.

However, over its lifetime, it can evolve due to interactions with other galaxies.

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Interacting Galaxies

Some images clearly show galaxies interacting with each other …

… but the full influence of collisions and mergers in galaxy evolution can be appreciated only through simulations.

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Galaxy Soup

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26

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Collisions

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27

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