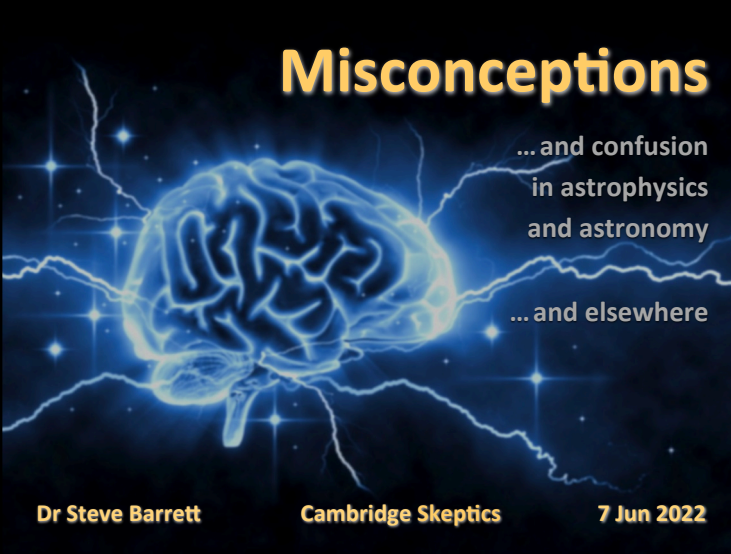


Misconceptions



Misconceptions

... and confusion
in astrophysics
and astronomy

... and elsewhere

Dr Steve Barrett Cambridge Skeptics 7 Jun 2022

Misconceptions

Using slides taken from ...

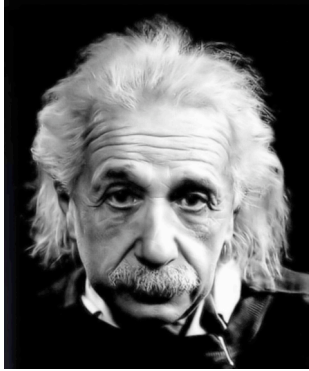
- Expanding Universe**
 - Where was the Big Bang?
 - Faster than the speed of light
- Matter**
 - Black holes suck
 - Dark matter is not dark
- Rocket Science**
 - Overcoming gravity
 - Parking at Lagrange 2
- Quantum Mechanics**
 - Words / Pictures / Maths
 - Common sense



UNIVERSITY OF LIVERPOOL

2

Incomprehensible



" The most
incomprehensible
thing about the
world ...
... is that it is
comprehensible "

UNIVERSITY OF LIVERPOOL

3

Misconceptions

Using slides taken from ...

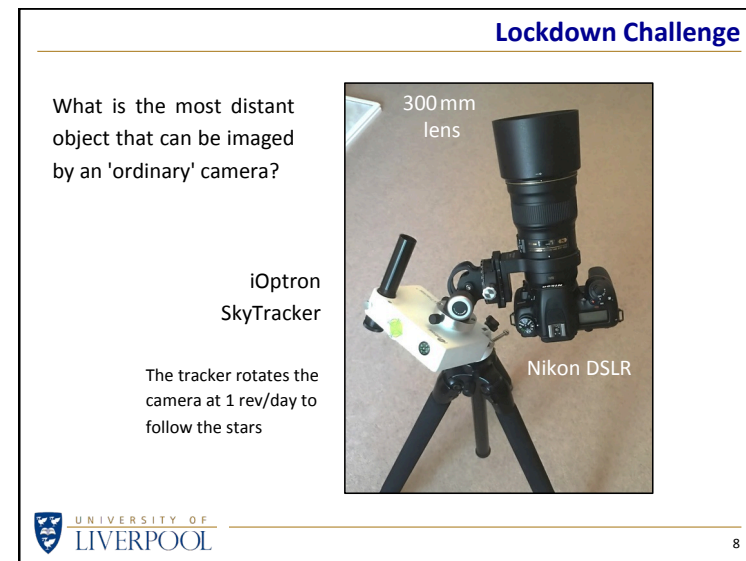
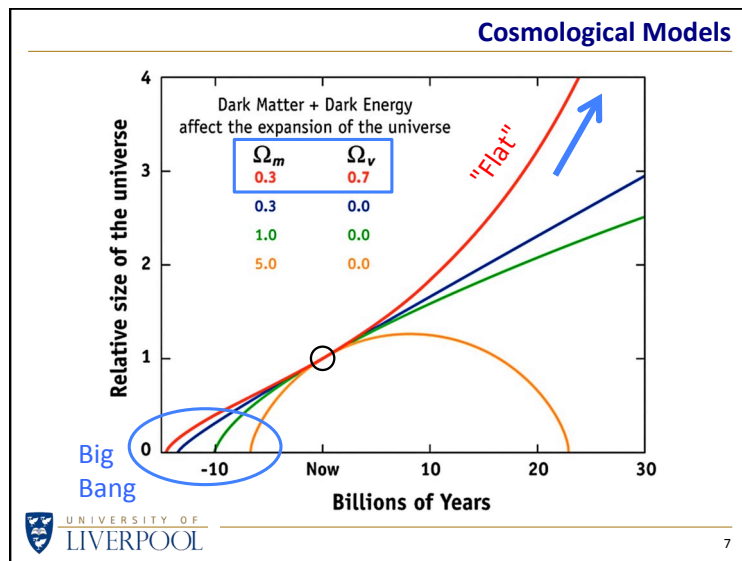
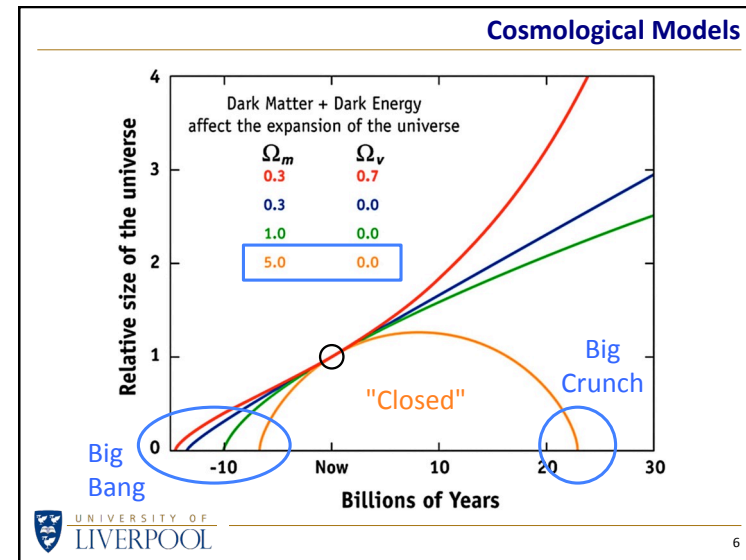
- Expanding Universe**
 - Where was the Big Bang?
 - Faster than the speed of light
- Matter**
 - Black holes suck
 - Dark matter is not dark
- Rocket Science**
 - Overcoming gravity
 - Parking at Lagrange 2
- Quantum Mechanics**
 - Words / Pictures / Maths
 - Common sense



UNIVERSITY OF LIVERPOOL

4

Misconceptions



Misconceptions

Imaging a Quasar

Most of the light from the quasar is focussed into one pixel

Just a pixel of the 20 Megapixel image

UNIVERSITY OF LIVERPOOL

9

Distance to the Quasar

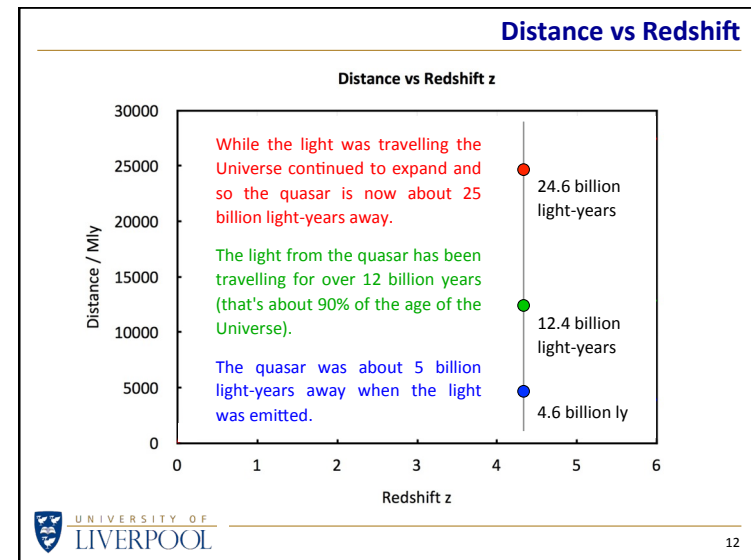
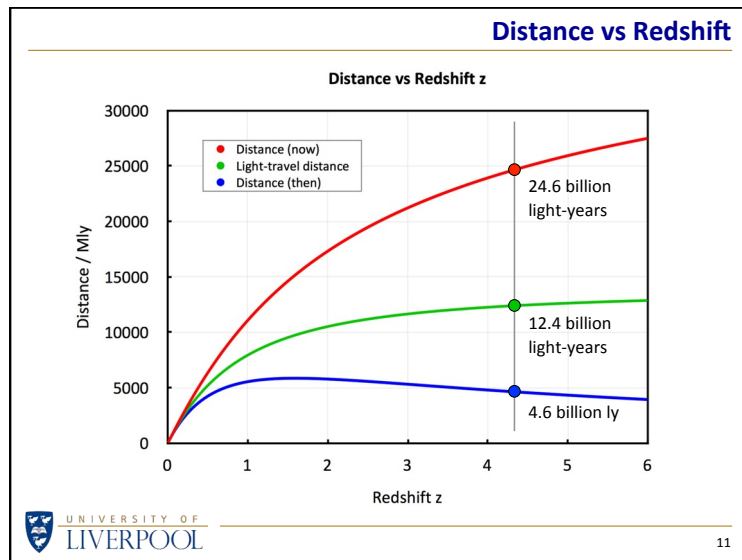
What distance has the light travelled to reach us?
That's tricky: Space continues to expand as the light travels.

It's like swimming against the tide...

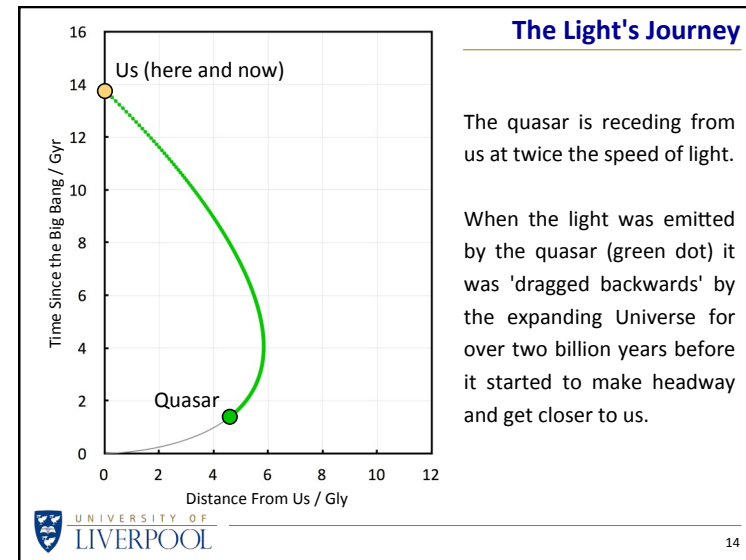
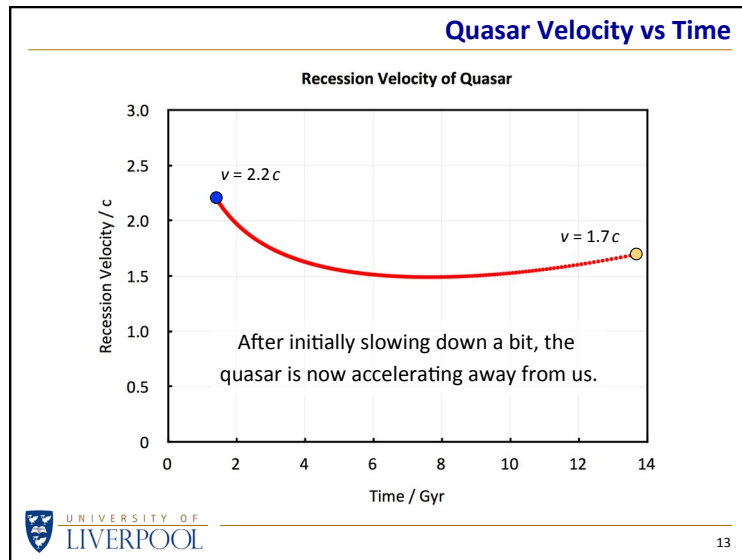
...or an ant walking along a rubber band that is being stretched.

UNIVERSITY OF LIVERPOOL

10



Misconceptions



Misconceptions

Using slides taken from...

Expanding Universe

- Where was the Big Bang?
- Faster than the speed of light

Matter

- Black holes suck
- Dark matter is not dark

Rocket Science

- Overcoming gravity
- Parking at Lagrange 2

Quantum Mechanics

- Words / Pictures / Maths
- Common sense

Ancient Light

Dark Matter

Fiat Lux

Warping Space and Time

The Beginning of Everything

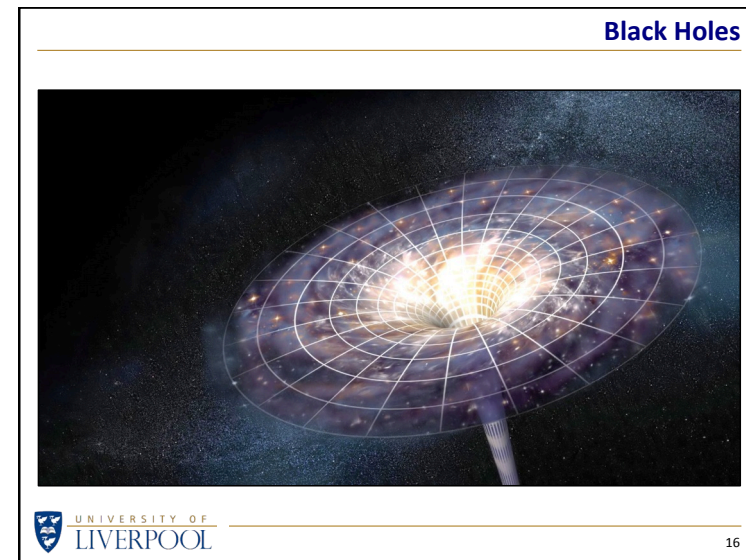
The End of Everything

It's Not Rocket Science!

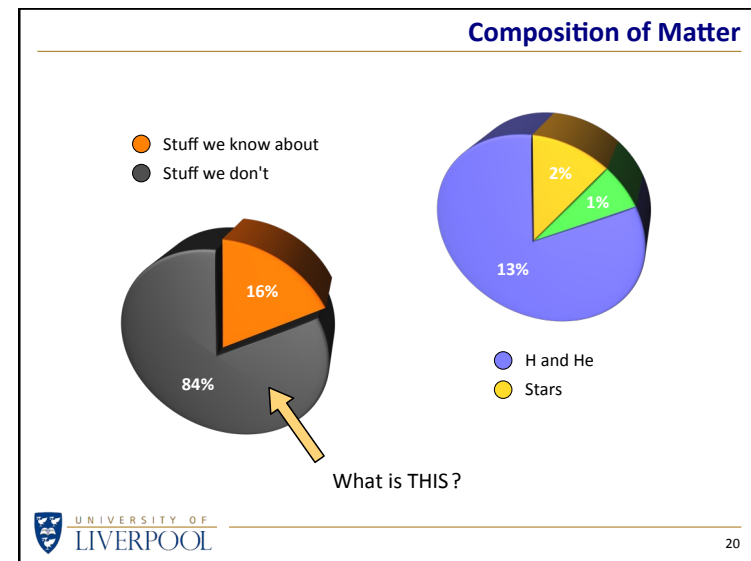
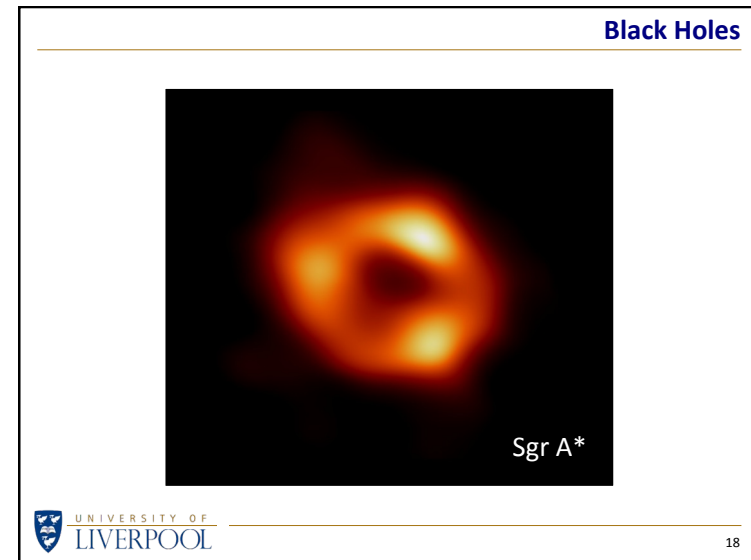
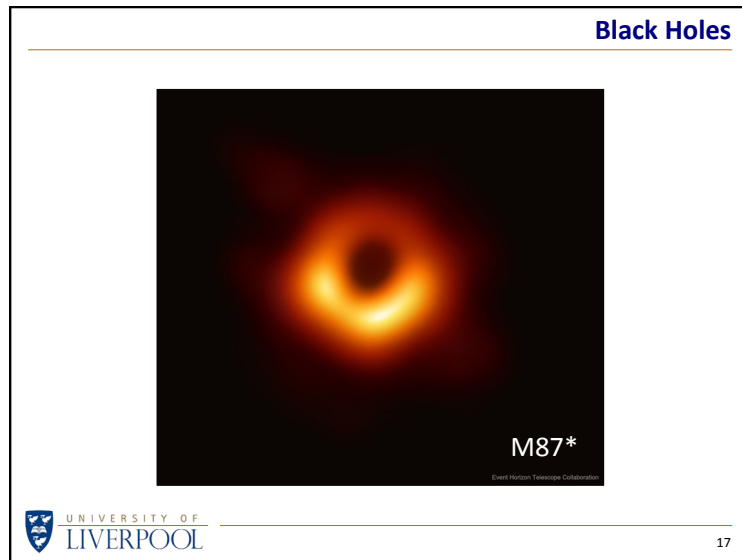
The Weird World of the Very Very Small

UNIVERSITY OF LIVERPOOL

15



Misconceptions

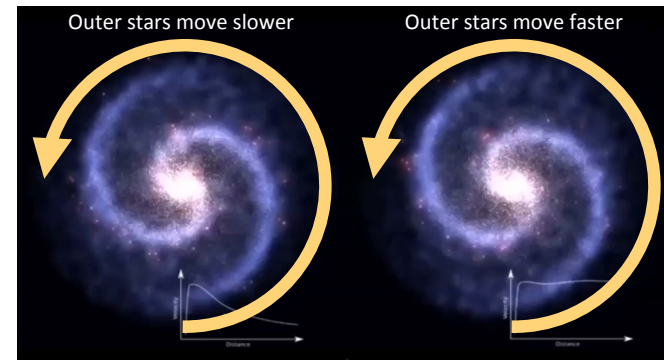


Misconceptions

Horsehead Nebula – Not Dark Matter



What Is the Evidence?



Without dark matter

With dark matter

Cosmic Web

When the very early Universe was the size of a golf ball it had very small variations in density ('dimples')...

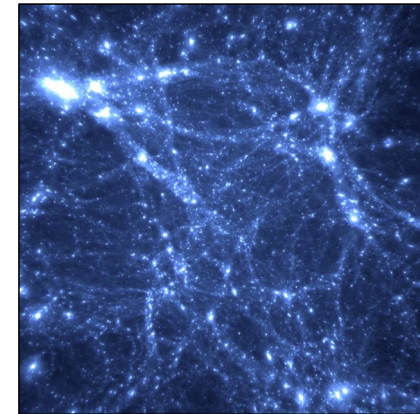
...and over billions of years these collapsed into a cosmic web of filaments and voids.



Cosmic Web

When the very early Universe was the size of a golf ball it had very small variations in density ('dimples')...

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

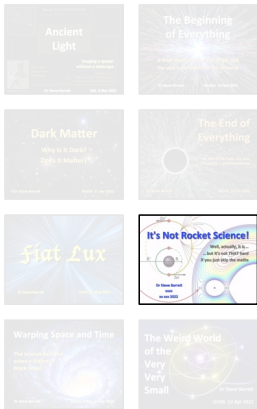


Misconceptions

Misconceptions

Using slides taken from ...

- Expanding Universe**
 - Where was the Big Bang?
 - Faster than the speed of light
- Matter**
 - Black holes suck
 - Dark matter is not dark
- Rocket Science**
 - Overcoming gravity
 - Parking at Lagrange 2
- Quantum Mechanics**
 - Words / Pictures / Maths
 - Common sense



UNIVERSITY OF LIVERPOOL

25

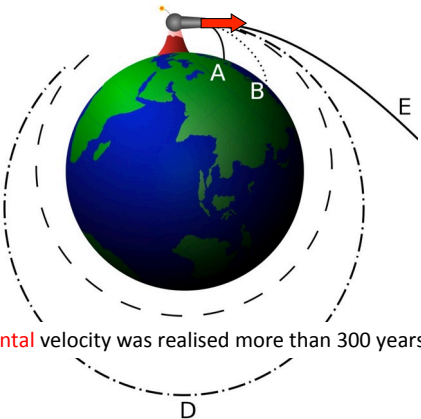
Rocket Science



UNIVERSITY OF LIVERPOOL

26

Newton's Cannonballs



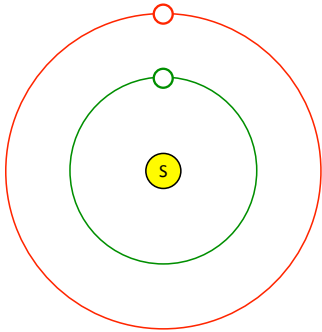
Isaac Newton
Principia 1686

The need for **horizontal** velocity was realised more than 300 years ago

UNIVERSITY OF LIVERPOOL

27

Orbit Size and Orbit Period



- Green planet is closer to Sun
- Gravitational pull from Sun is stronger
- Planet moves faster to stay in orbit
- Shorter period ('year')

- Red planet is further from Sun
- Gravitational pull from Sun is weaker
- Planet moves more slowly to stay in orbit
- Longer period ('year')

UNIVERSITY OF LIVERPOOL

28

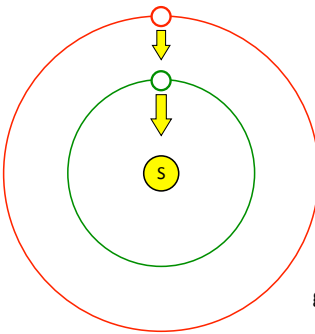
Misconceptions

Orbit Size and Orbit Period

The arrows show the gravitational force of the Sun on each planet.

At a greater distance, the force is less.

Is that always the case?



We can't change the gravitational pull of the Sun ...

...but we can arrange it so that an object in the red orbit feels an additional gravitational force.

UNIVERSITY OF LIVERPOOL

29

Lagrange Points

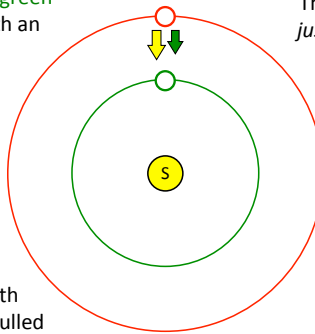
Let's assume that green is planet Earth with an orbital period of exactly 1 year.

The red orbit has a period of *more* than 1 year.

What if the red orbit is close enough to the Earth that an object is pulled by both the Sun **AND** the Earth?

There is a red orbit at *just* the right distance such that the extra pull from the Earth makes the red object orbit faster with a period of 1 year.

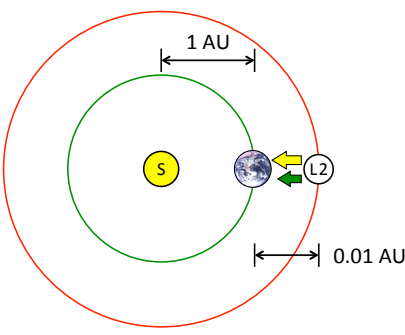
That would mean that the red object would orbit the Sun 'with' the Earth.



UNIVERSITY OF LIVERPOOL

30

Lagrange Point L2

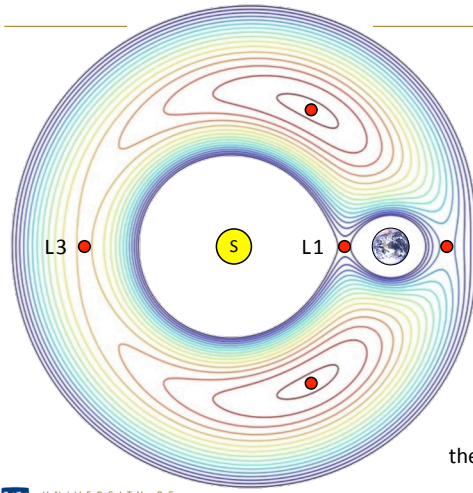


Not to scale!

UNIVERSITY OF LIVERPOOL

31

Parking at L2



The ability of a spacecraft to 'park' at a Lagrange point is sometimes visualised using this doughnut.

Imagine that the contours represent height and think about a ball wanting to roll 'downhill'.

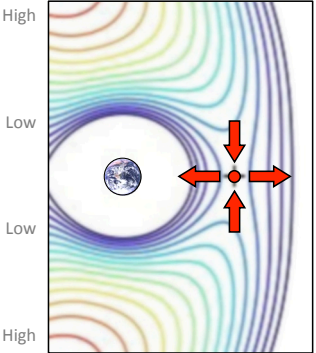
Look more closely at the contours around L2...

UNIVERSITY OF LIVERPOOL

32

Misconceptions

Parking at L2



The arrows show the directions of 'downhill' in the vicinity of L2.

L2 is *not* on a 'hilltop'.

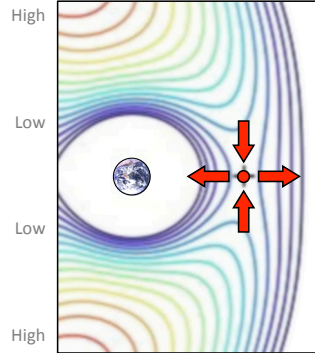
L2 is *not* in a 'well'.

L2 is at a saddle point.

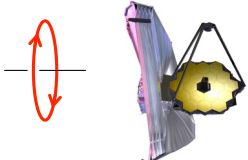
UNIVERSITY OF LIVERPOOL

33

Parking at L2



Hence the JWST can park in a 'halo' orbit around L2, but it will slowly drift towards Earth...



... and so will need a station-keeping nudge every few months.

UNIVERSITY OF LIVERPOOL

34

Misconceptions

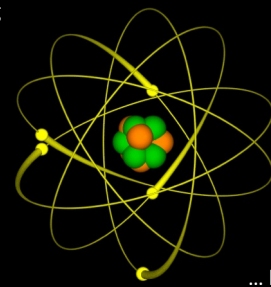
Using slides taken from...

- Expanding Universe**
 - Where was the Big Bang?
 - Faster than the speed of light
- Matter**
 - Black holes suck
 - Dark matter is not dark
- Rocket Science**
 - Overcoming gravity
 - Parking at Lagrange 2
- Quantum Mechanics**
 - Words / Pictures / Maths
 - Common sense

UNIVERSITY OF LIVERPOOL

35

Bohr Model



This might be how we imagine atoms with electrons buzzing around a nucleus like bees ...

... but it doesn't show us that all the electrons have different energies

UNIVERSITY OF LIVERPOOL

36

Misconceptions

Bohr Model

It is better to think of the electrons in different sized orbits ...

... or concentric shells surrounding the nucleus

UNIVERSITY OF LIVERPOOL

37

Electron 'Clouds' of Probability

UNIVERSITY OF LIVERPOOL

38

How Can We Describe Atoms?

Particles
Waves
Orbits
Spin
Energy

Words

Pictures

Maths

$H\psi = E\psi$

UNIVERSITY OF LIVERPOOL

39

How Can We Describe Atoms?

UNIVERSITY OF LIVERPOOL

40

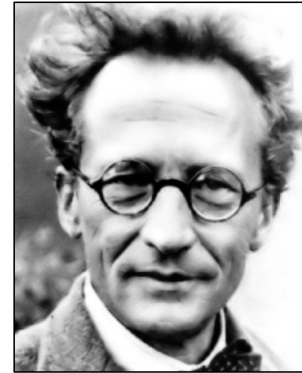
Misconceptions

Heisenberg



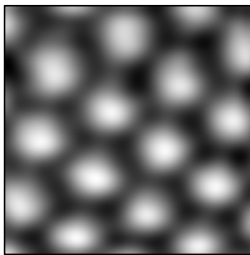
" We wish to talk about the structure of atoms. But we cannot talk about atoms in ordinary language "

Schrödinger



" Atomic physics has shown that atoms have no meaning, but can only be understood in experimental measurement "

A World of Atoms



On this scale, a grain of sand would be about the size of the Moon.

" To see a world in a grain of sand ... "

William Blake

850 pm

Misconceptions

... and confusion
in astrophysics
and astronomy

... and elsewhere

www.liverpool.ac.uk/~sdb/Talks

Dr Steve Barrett

Cambridge Skeptics

7 Jun 2022