

## **Heaven and the discovery of deep space**

HI3T5 Value in the Age of Reason

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Dr. Michael Bycroft

*This handout is designed to be used in conjunction with the planetarium show*

We can talk about a 'discovery of deep space' in the decades around 1800. This was analogous to the 'discovery of deep time' happening in the same period in the earth sciences. To understand these events, we need to become acquainted with the night sky and with the history of astronomy up to about 1700.

### **Orientation**

- Some things to see in the sky, looking south-west just after sunset in early Spring
- The Moon, and the planets Venus, Mars, and Jupiter
- The Winter Hexagon, an array of bright stars including Sirius, the brightest star in the night sky
- Part of the Milky Way
- Constellations such as Orion, with its rectangle of four very bright stars
- Some constellations of the zodiac, ie. those through which the sun passes in the course of the year
- In the northern sky: the Big Bear, Little Bear, and Pole Star; plus the bright stars Arcturus and Deneb, the latter part of the Swan constellation

### **Ancient and medieval astronomy**

- Imagine a keen stargazer in the Mediterranean basin in ancient times
- No telescopes, no observatories, but good eyesight and regular viewing
- In the northern sky, stars revolve around the pole star
- Relative positions of stars don't change as they revolve
- Nor do the stars move relative to each other over the course of the year
- Stars rise in East and set in West much like the sun
- The further south you go, the lower the pole star appears in the sky
- All this suggested a simple model of the universe, the 'two-sphere' model
- The Earth is spherical and sits at the centre of a larger sphere that holds the stars and rotates on its axis once every 24 hours
- The sun and planets each sit on their own sphere that revolves around the Earth

## The Copernican Revolution

- The big change in astronomy in early modern Europe (c. 1450-1700) was to place the sun rather than the earth at the centre of the solar system
- This gave a simpler account of the motions of planets, eg. the 'retrograde motion' of Mars
- At the same time, the telescope showed that the moon and planets were not so different from Earth, eg. the moon has 'mountains,' Jupiter has moons...
- The great synthesis of these ideas was Isaac Newton's *Mathematical Principles of Natural Philosophy* (1687), which introduced the idea of universal gravitation
- BUT Newton had little to say about the stars
- More generally, the Copernican revolution was about the solar system not the stars
- Yes, the idea of the 'sphere of fixed stars' had been abandoned, but no-one had a better idea about the distribution of the stars through space

## The Herschels

- William Herschel (1738-1822) and his sister Caroline Herschel (1750-1848)
- Born in Hanover, migrate to England, work as musicians in Bath
- The key to their astronomy was a) powerful telescopes and b) team-work
- William discovers Uranus, 13 March 1781, using his telescope to distinguish this planet from the surrounding stars
- His telescopes also helped to 'resolve double stars', ie. distinguish between pairs of stars that seemed to be just one star when viewed with lesser telescopes
- Perhaps these double stars revolved around each-other due to gravity?
- The same telescopes helped to resolve nebulae, ie. milky-white patches in the heavens, many of which turned out to be clusters of stars
- Perhaps these clusters were formed under the influence of gravity?

## The Herschel's 'sweeps'

- William and Caroline start a systematic search for double stars and nebulae in 1782, under the patronage of George III at Datchet, near Windsor Castle
- Two decades, 2500 nebulae, hundreds of double stars
- Two 20-foot telescopes, one 12-inch mirror, one 18-inch mirror
- The telescope points due south; William watches stars 'sweep' through the eyepiece; he calls out his findings to Caroline, who writes them down
- Some nebulae seem like stars condensing out of a fluid, eg. NGC 1514, 'crystal ball nebula'
- Others have distinctive shapes, eg. the spiral shape of the Andromeda nebula
- What would *our* nebula, the Milky Way, look like from a distance?
- Ultimately these observations led to a 'biological' (Michael Hoskin) view of the universe, with stars and star clusters going through a 'life cycle' under the influence of gravity

*What did this have to do with the evaluation? What did it mean to 'evaluate' the heavens in the eighteenth century?*