## Hubble Vision

#### Dr Martin Hendry Dept of Physics and Astronomy University of Glasgow



#### THE UNIVERSE YOURS TO DISCOVER

## INTERNATIONAL YEAR OF ASTRONOMY 20009





DACE, January 2009

#### NICOLAI COPERNICI

net, in quo terram cum orbe lunari tanquam epicyclo contineri diximus. Quinto loco Venus nono menfe reducitur. Sextum deniqt locum Mercurius tenet, octuaginta dierum spacio circu currens, ln medio ucro omnium refidet Sol. Quis enim in hoc



pulcherimo templo lampadem hanc in alio uel meliori loco po neret, quàm unde totum fimul poísit illuminare: Siquidem non inepte quidam lucernam mundi, alti mentem, alti rectorem uocant. Trimegiftus uifibilem Deum, Sophodis Electra intuente omnia. Ita profecto tanquam in folio re gali Sol refidens circum agentem gubernat Aftrorum familiam. Tellus quoce minime fraudatur lunari minifterio, fted ut Ariftoteles de animalibus ait, maxima Luna cu terra cognatione habet. Concipit interea à Sole terra, & impregnatur annuo partu. Inuenimus igitur fub hae



#### Nicolaus Copernicus 1473 – 1543 AD





Galilean Moons: 1610

#### Galileo Galilei: 1564 – 1642 AD









"I have observed the nature and the material of the Milky Way. With the aid of the telescope this has been scrutinized so directly and with such ocular certainty that all the disputes which have vexed philosophers through so many ages have been resolved, and we are at last freed from wordy debates about it.

The galaxy is, in fact, nothing but a collection of innumerable stars grouped together in clusters. Upon whatever part of it the telescope is directed, a vast crowd of stars is immediately presented to view. Many of them are rather large and quite bright, while the number of smaller ones is quite beyond calculation."

from The Starry Messenger (1610)





- The stars are VERY far away. The nearest star (after the Sun) is about 40 million million km from the Earth. It takes light more than 4 years to travel this distance.
- If the distance from the Earth to the Sun were the width of this screen, the next nearest star would be in **Rome**

#### Stars radiate equally in all directions



#### This gives rise to the Inverse-Square Law:

The apparent brightness of a star falls off with the square of its distance



#### Betelgeuse

•

Rigel

gel

Betelgeuse

Sirius Rigel

Ś

SW SV



We measure the intrinsic brightness of a star by its luminosity

Luminosity, L (watts)

e.g. for the Sun

 $L = 4 \times 10^{26} \,\mathrm{W}$ 

### 1 Watt = 1 Joule of energy per second

= power needed to lift 1 kg bag of sugar vertically about 10cm in one second





Luminosity varies with colour (see later)

*e.g. consider* Rigel *and* **Betelgeuse** in Orion



Luminosity varies with colour (see later)

*e.g. consider* Rigel *and* **Betelgeuse** in Orion

Adding up luminosity L at all colours

 $\Rightarrow$  Bolometric luminosity

e.g. for the Sun

$$L_{\rm bol} = 4 \times 10^{26} \,\mathrm{W}$$



# How do stars and planets form?

## from Nebulae



# How do stars and planets form?

## from Nebulae





























### **The Orion Nebula**















## **Forming stars**





versus fravity



Gravity trying to collapse the cloud

**Collapse often caused** initially by the shock wave from a supernova





Gravity trying to collapse the cloud

**Collapse often caused** initially by the shock wave from a supernova



AB Aurigae Disk PRC99-21 • STScI OPO • C. Grady (NOAO at NASA Goddard Space Flight Center) and NASA





#### Hydrogen fusion – fuelling a star's nuclear furnace







## 300,000 kms<sup>-1</sup>



The speed of light is the ultimate speed limit in the Universe



We can plot the temperature and luminosity of stars on a diagram

Stars don't appear everywhere: they group together, and most are found on the Main Sequence



Stars on the Main Sequence convert hydrogen into helium.

Stars like the Sun can do this for many billions of years, using the P-P chain of nuclear reactions





Stars on the Main Sequence turn hydrogen into helium.

Blue stars are much hotter than the Sun, and use up their hydrogen in a few million years

