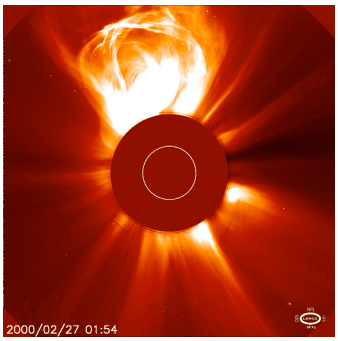
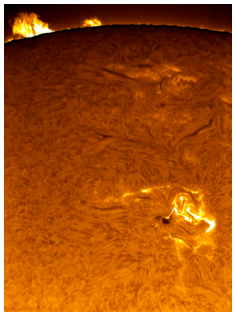
Space Weather…how the Sun affects the Earth

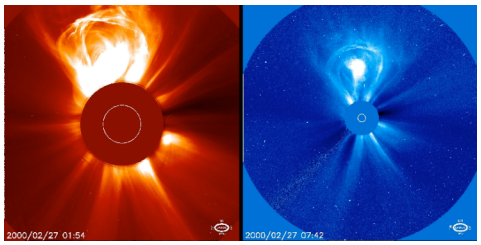


Solar activity includes two violent types of events

- Solar flares →
- Coronal mass ejections



Coronal mass ejections



A loop of matter "blasts off" from the Sun

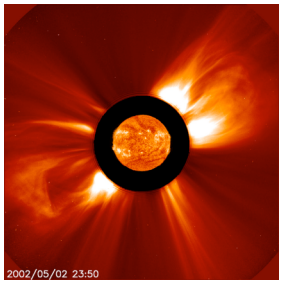
Illustrations of coronal mass ejections

http://sohowww.nascom.nasa.gov/gallery/Movies/C3May97/C3May97sm.mov

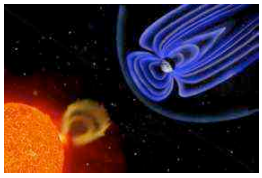
http://sohowww.nascom.nasa.gov/gallery/Movies/C2prot00/C2prot00.mov

Why are flares and coronal mass ejections important?

- They are dangerous! They can generate levels of radiation in interplanetary space that are lethal
- They are part of, and play a role in, the development of the **solar wind**



When large coronal mass ejections impact the Earth, they produce major auroral events

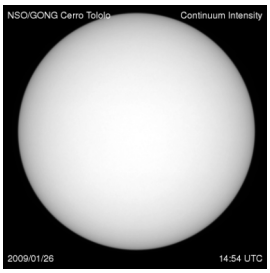


Artists conception, based on computer calculations

http://sohowww.nascom.nasa.gov/gallery/Movies/recon/reconsm.mov

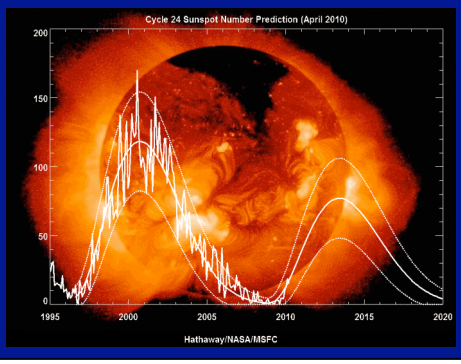
Sunspots and solar activity: they come and go

Sept. 21, 2000

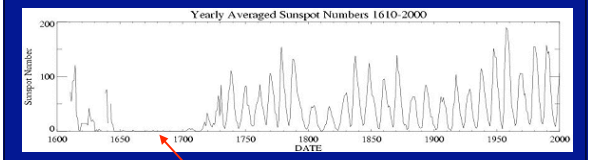


Jan. 26, 2008

The 11 year solar cycle: where are we now?

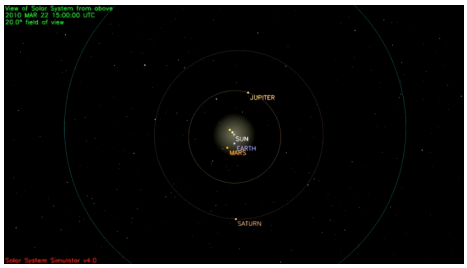


The 11 year solar cycle goes back to the time of Galileo



Maunder Minimum

Next topic: where did it come from?

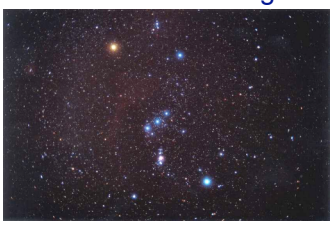


How did the solar system form? What processes were going on?

Formation of the solar system

- First question: how long ago did this happen?
- Nobel Prize winner Hannes Alfven: "the study of the origin of the solar system is archaeology, not physics".
- Second question: what is the principal object in the solar system?
- The answer to the second question explains the title to the chapter in the book which covers this topic, chapter 18

An important way in which Alfven's statement is wrong

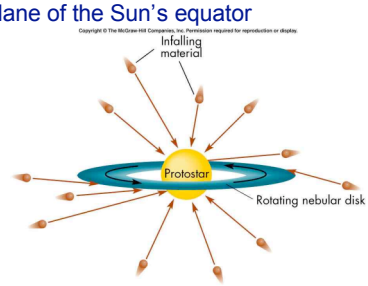


Star formation, and planet formation, are going on **right now** at other places in our Galaxy. Some of these new star systems are relatively close

Our understanding of stars, and star formation, means that the solar system began as a huge cloud of (mainly) hydrogen and helium collapsing under its own gravity. Most of this matter went into the Sun. Some tiny part of it ended up as the rest of the solar system.

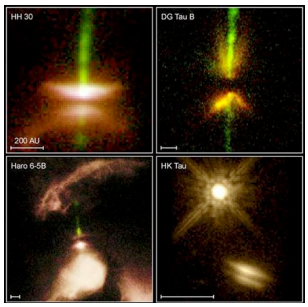
Leads to the concept of the **solar nebula** for the cloud of matter that surrounded the "proto-Sun"

The cloud would have been rotating (even a little bit). This means the inflowing material would have formed an accretion disk in the plane of the Sun's equator

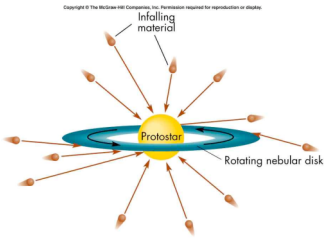


With today's astronomical instrumentation, we can see this in young star systems called Herbig-Haro objects

What do these disks remind you of in the solar system?



The idea of an accretion disk in the solar nebula 4.6 billion years ago, from which the planets formed, is consistent with the observation that all of the planets revolve in the same direction, that of the rotation of the Sun

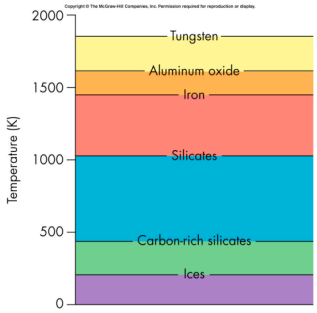


How do we account for one of the most basic properties of the solar system; the difference between the Terrestrial and Jovian planets?

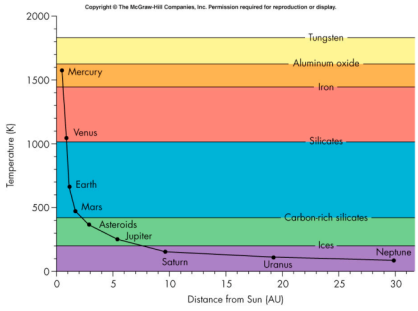
We think this is a consequence of different temperatures in different parts of the solar nebula

"the solar nebula was heated by release of gravitational energy…it was hottest near its center, where temperatures may be been 2000K…"

Consider what substances would have condensed out of the solar nebula at different temperatures



Now consider what we think the temperatures were at different parts of the solar nebula



The appears to be a connection between the types of materials which were condensing (precipitating) in the solar nebula, and what sort of planets formed there