

Constructing the Solar System: A Smashing Success!

Lecture 3: Asteroids and Meteorites— Our eyes in the early Solar System

Thomas Davison

October 27, 2012

1 Introduction

Last lecture, we learned how planetesimals formed from the disk of gas and dust surrounding the young Sun (the Solar Nebula). This week, we will look in detail at some of the bodies still present in the Solar System that have survived from that time (i.e. they haven't been ejected from the system or accreted onto the Sun or planets). There are several different types of objects that we can look at to determine the conditions under which they formed: e.g. asteroids, comets and meteorites.

2 Asteroids

Asteroids are bodies that formed in the early Solar System, and are likely to represent planetesimals that survived the period of planet building and are still in orbit around the Sun today. Most asteroids are found in orbits between Mars and Jupiter (although some are on Earth-crossing orbits, and some follow similar orbits to Jupiter—the Trojans). Asteroids are smaller than planets, and typically range from meters up to a few hundred kilometers in size. The first known asteroid, Ceres, was discovered in 1801. Three more discoveries followed in the next six years. By 1900, a few hundred asteroids were known, and by 1980, we had discovered around 9000 asteroids. Then, with the introduction of computerized methods of detection and more sophisticated observational techniques, the number of known asteroids exploded. We now know of more than half a million asteroids, and that number is still growing by thousands of new asteroids every month.



Figure 1: An example of an asteroid. This image of Mathilde is courtesy of NASA. Impact craters are visible on the surface.

3 Gaps in the orbits

Some gaps are present in the orbits of the asteroids (at certain distances from the Sun). These are caused by orbital *resonances* with the giant planet Jupiter. Every couple of orbits around the Sun, asteroids in these resonances receive a small boost in their orbital velocity from Jupiter's gravity, moving them into slightly different orbits. We'll look more at the dramatic effects that orbital resonances had during planet formation in next week's lecture.

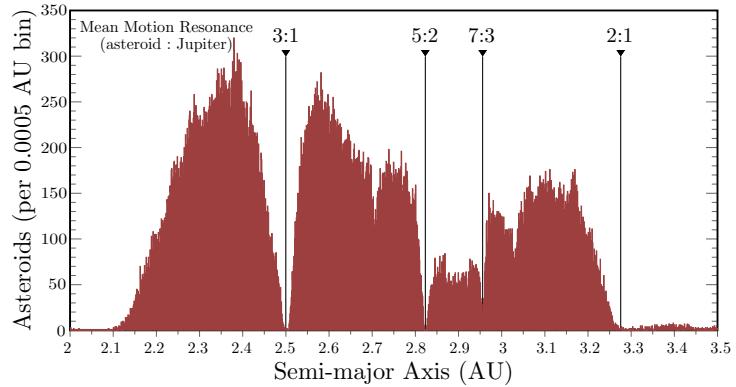


Figure 2: Histogram of the number of asteroids at a given distance from the Sun. The gaps in the distribution are caused by interactions with Jupiter's gravity. Image adapted from Alan Chamberlain (JPL-Caltech).

4 Meteorites

Meteorites are rocks that fall to Earth from space; they have a variety of origins. Most come from asteroids, while some originated on the Moon or Mars. From their chemistry, we can infer the conditions under which they formed and group them with other meteorites with similar characteristics—which are likely to have come from the same parent body (i.e. asteroid).



Figure 3: Two different types of meteorites. On the left, a primitive, stony chondritic meteorite, thought to have formed very early in the Solar System. On the right, an iron meteorites, which formed in the core of a large asteroid. An impact later broke the asteroid apart, and sent this meteorite on a collision course with Earth. Both meteorites are around 4 inches wide. Images courtesy of H. Raab.

5 Impacts

We see evidence of impacts on all asteroids that we have imaged (i.e. impact craters are present on all asteroid surfaces). The low density of some asteroids also suggests they have suffered violent impacts that broke them apart; they would have subsequently re-accumulated under their own gravity, leaving them with gaps (or pores) between chunks of rock—leading to a lower density. Meteorites also show evidence of collisions: for example, shock metamorphism (alteration of the rocks under extreme pressure and temperature) is observable in many meteoritic samples. We use the details of these shock indicators to build a history for the meteorite's parent body—we will examine these ideas more in a later lecture.

6 Next lecture

In the next lecture, we will discuss how planetesimals grew into planets, and what led to the striking differences between the inner and outer planets. We will also look at the influence of the planet building epoch on the population of planetesimals, and how that affected the structure of the asteroid belt.