Paris, January 28th, 2014

Press release

A new view of the main asteroid belt

Two scientists, including an astronomer at the Paris Observatory, at the Institute for celestial mechanics and ephemeris calculations (Institut de mécanique céleste et de calcul des éphémérides - IMCCE (Observatoire de Paris/CNRS/université Pierre et Marie Curie/université de Lille 1) have published in the January 30th issue of the journal *Nature*, a complete compositional map of the asteroids which are in the main belt. This work constitutes a complete revision of the ideas widely accepted for the last 30 years, and confirms the new paradigms for the formation and evolution of the solar system.

Research
Training
Scientific Culture

Artist's view of the protoplanetarydisc surrounding the young Sun, when the planets werre being born. © Nasa

Contact scientist

Observatoire de Paris

Benoît Carry
Astronomer
IMCCE
+33 (0) 1 40 51 22 71
+33 (0) 7 86 96 75 06
benoit.carry@obspm.fr

Press contact

Observatoire de Paris

Frédérique Auffret
+33 (0) 1 40 51 20 29
+33 (0) 6 22 70 16 44
presse.communication@obspm.fr

The main asteroid belt is situated between the orbits of Mars and Jupiter; it is made up of millions, if not billions of small rocky fragments and dust. The total mass of all the asteroids comes to about 1/1000th of the mass of the Earth. Their sizes span a very wide range, from a few centimetres to hundreds of kilometres.

For planetologists, asteroids constitute a primary source of information about the earliest stages of the formation of the solar system. They are the remains of the primordial nebula which was created 4,5 billion years ago. The emerging Sun was surrounded by a disc of dust and gas, within which the planets gradually formed through gravitational attraction. Asteroids are small bodies which failed to combine into larger structures. Since they have hardly evolved, they carry a record of the conditions which reigned at the time when the Earth and the other Earth-like planets were being formed, when they nad not yet «differentiated[1]» into the core-mantle-crust structure.

Since the 1980s, scientists have generally assumed that the solar system has not changed much over the course of its history: bodies have remained there where they were formed. The first analyses of asteroidal compositions led to a classification according to their heliocentric distance, involving a transition from evolved, "hot" bodies, close to the Sun, to more primitive, "cold", bodies, farther from the Sun.

The decade starting in the year 2000 brought significant changes to this model, and hightlighted exceptions: asteroids which were formed in principle in a "hot" environment have been found more or less far from the Sun, and vice versa. At the same time, the search for exoplanets, and in particular the discovery of «hot Jupiters», i.e. gas giants orbiting close to their star, has seriously undermined the notion of static planetary systems.

Two astronomers, Francesca DeMeo from the Massachussetts Institute of Technology – MIT (U.S.A.) and Benoît Carry from the Paris Observatory (IMCCE - Observatoire de Paris/CNRS/université Pierre et Marie Curie/université de Lille 1) have made a major contribution to these ideas, with a complete map of the distribution of asteroidal compositions in the main belt, recently published in the journal *Nature*. Using images taken from the Sloan Digital Sky Survey SDSS[2], the scientists found over 100 000 cases in which by chance appeared an asteroid belonging to our solar system. Since the SDSS was made at verious wavelengths, these images have enabled the composition of 100 000 asteroids larger than 5 km to be determined, and to range them as a function of size and position in the solar system.

This new map shows that, as far as the large (equal to or larger than 50 km) asteroids are concerned, the conventional view remains unchanged: the farther they are from the Sun, the more primitive they appear to be. However, in the case of the small asteroids (in

[1]Differentiation is the process whereby the various materials making up a planetary interior separate into distinct layers: the heavy elements (such as metals), attracted towards the hot planetary centre, make up the core, while the less dense elements constitute the mantle and the crust.

[2] Relevé de ciel profond lié à un télescope de 2,5 m de Apache Point du Nouveau Mexique qui intègre 100 millions d'objets célestes, des étoiles et des galaxies du ciel boréal. Sur certains clichés, des astéroïdes apparaissent fortuitement.

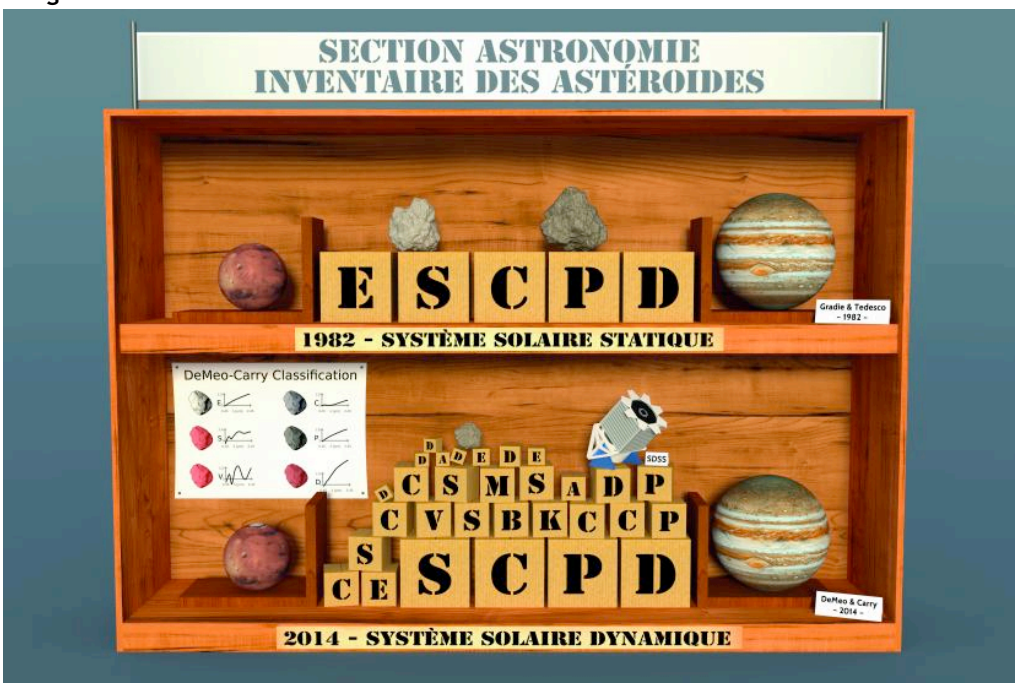
particular, those between 5 and 20 km in size), this view must now be significantly revised, since what seemed in the 2000s to be exceptions now turn out to be the norm: in the vicinity of Mars have been found asteroids which were not recorded in the old surveys, but which are quite similar to the cold objects generally situated beyond the orbit of Jupiter.

This new view of the main asteroid belt fits the latest theoretical models for the history of the solar system, while nevertheless raising new questions. With the publication of the Nice model in 2005, scientists now claim that everything in the solar system, including the planets, has migrated enormously, and that the asteroids were created at various distances from the Sun, before ending up in the main belt. From these models emerges the great variety of asteroids in the main belt, which has now to be thought of as the dumping ground of the young solar system.

Although the new map does bear witness to this variety, the details are not all in such good agreement with the models, and particular the presence of "cold" bodies close to Mars. «*Sorting out this tangle is the key to understanding how the solar system evolved from its beginnings*» points out Benoit Carry. So far, dynamic models for the evolution of the solar system have been unable to reproduce what is observed. The details in these maps, unknown till now, will be exploited by theorists and help guide them to uncover our past.

Reference
This research is in press:
« Solar System evolution from Compositional mapping of the asteroid belt », F. E. DeMeo et B. Carry, *Nature*, 30 janvier 2014.
doi:10.1038/nature12908

Image



Caption: Two compositional maps of the asteroid belt between Mars and Jupiter, made 30 years apart. The presence of «primitive» asteroids – in particular those of type C and D – towards the interior of the asteroid belt, close to the orbit of Mars, can no longer be doubted. Models for the formation and evolution of the solar system must now take these characteristics into account.