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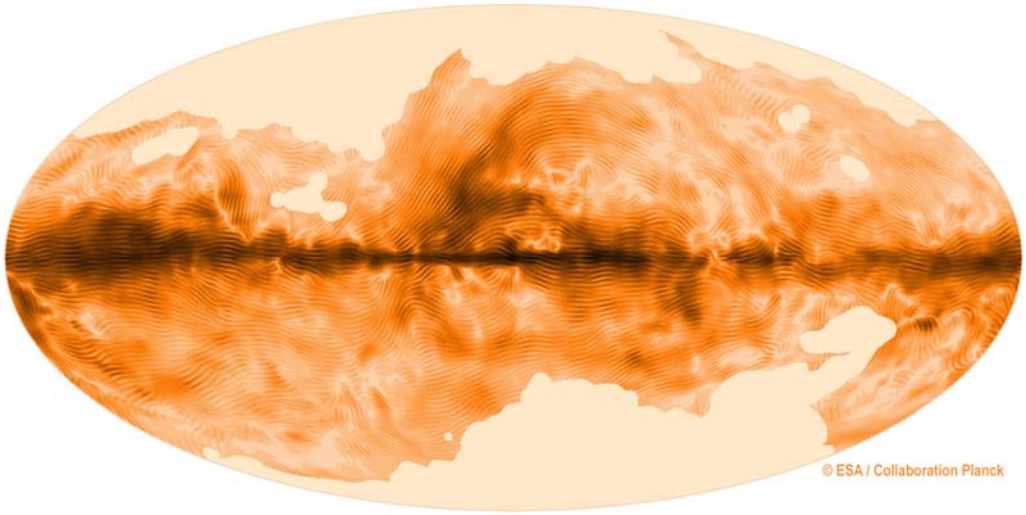
Planck reveals the magnetic fingerprint of our Galaxy

The Milky Way's magnetic field is revealed in a new map released by the European Space Agency (ESA)'s Planck mission. This image was obtained from the first all-sky observations of 'polarized' light emitted by interstellar dust in our Galaxy. Numerous researchers and engineers at the CNRS, CEA, CNES and various Universities are taking part in the Planck mission, which continues to provide a wealth of data. Four papers recently submitted to the journal *Astronomy & Astrophysics* analyze these results.



The magnetic field of the Milky Way seen by the Planck spacecraft. Darker regions correspond to stronger polarized emission, and the striations indicate the direction of the magnetic field projected on the plane of the sky. © ESA – Planck collaboration

Light is a very familiar form of energy, although some of its properties are not easily accessible. One of these—polarization—is a source of information for researchers. In space, the light emitted by stars, gas or dust can be polarized in several ways. By measuring this polarization, astronomers can study the physical processes that give rise to it, in particular the properties of the magnetic fields in our Galaxy's interstellar medium[1].

The map shown here was obtained using detectors on the Planck spacecraft that act rather like the astronomical equivalent of polarized sunglasses. The swirls, loops and arches in the image trace the structure of the magnetic field in our Galaxy. The image shows the large-scale organization of part of

[1] Knowledge about our Galaxy's magnetic field is of fundamental importance, since it is thought to govern or influence a wide range of phenomena, such as the paths of electrically charged particles (cosmic rays) and star formation.

the Galactic magnetic field. The dark band corresponds to the Galactic Plane, where polarized emission is especially bright. The general structure reveals a regular pattern in which the magnetic field lines are predominantly parallel to the plane of the Milky Way.
The observations also reveal variations in the direction of polarisation within the clouds of matter near the Sun seen above and below the dark band. These provide evidence of changes in the direction of the magnetic field, whose cause is being studied by astrophysicists.

Regions at high Galactic latitudes have been masked. The signal is weaker there, and more work is required to measure the polarization of our Galaxy and separate it from that of the Cosmic Microwave Background.

Beyond our Galaxy

Planck has already mapped the brightness of the Universe's Cosmic Microwave Background in unprecedented detail, and researchers are now scouring the data to measure the polarization of this light. This is one of the main goals of the Planck mission, since this polarization could reveal the presence of primordial gravitational waves generated immediately after the birth of the Universe.

In March 2014, scientists from the BICEP2 collaboration announced the first detection of such a signal in data collected using a ground-based telescope observing a small patch of sky (1%) at a single frequency. Their result relies on the assumption that the polarization of our Galaxy's foreground emissions is negligible in this region.

By the end of 2014, the Planck collaboration will release data based on all-sky observations in seven frequency bands in which the detectors are sensitive to light polarization. This multi-frequency data should enable astrophysicists to estimate the primordial polarized signal and separate it from our Galaxy's foreground signal. This study will open the way to a much more detailed investigation of the early history of the Universe, from its expansion when it was a mere fraction of a second old until the birth of the first stars several hundred million years later.

ABOUT THE PLANCK MISSION

Launched in 2009, the European Space Agency (ESA) spacecraft Planck has mapped the entire sky in nine frequency bands at submillimeter wavelengths, between the far infrared and radio-wave regions. Data from the HFI High Frequency Instrument were key to these findings about the magnetic field. The HFI instrument, designed and assembled under the supervision of the Institut d'Astrophysique Spatiale (CNRS/Université Paris-Sud) with funding from CNES and CNRS, collected scientific data from 13 August 2009 to 14 February 2012.

The contribution of French research to the Planck mission

France is responsible for the Planck-HFI High Frequency Instrument, whose data have played a key role not only in the cosmological results but also in numerous galactic and extragalactic results. It cost €140 million to build, involving 80 researchers from ten CNRS, CEA and University laboratories. France provided more than 50% of the funding needed to build it as well as 100% of the funding for data processing: half came from CNES, and the other half from CNRS, CEA and the Universities. France also took part in the funding of the mission itself through its financial contribution to ESA's scientific program, i.e. 15% of the cost of the mission.

Exploitation of the scientific results is chiefly carried out by CNRS, in particular with Jean-Loup Puget (from IAS), Principal Investigator, and François Bouchet (IAP), Co-Principal Investigator.
The following French laboratories were involved in building the HFI instrument and in analyzing its data (from the raw data to the maps for each frequency), as well as in the astrophysical and cosmological interpretation of all the data from the Planck mission:

- APC, AstroParticule et Cosmologie (Université Paris DiderotlCNRSlCEAlObservatoire de Paris), Paris.
- IAP, Institut d'Astrophysique de Paris (CNRSlUPMC), Paris.
- IAS, Institut d'Astrophysique Spatiale (Université Paris-SudlCNRS), Orsay.
- Institut Néel (CNRS), Grenoble.
- IPAG, Institut de Planétologie et d'Astrophysique de l'Observatoire des Sciences de l'Univers de Grenoble (CNRSlUniversité Joseph Fourier), Grenoble.
- IRAP, Institut de Recherche en Astrophysique et Planétologie de l'Observatoire Midi-Pyrénées (Université Paul SabatierlCNRS), Toulouse.
- CEA-IRFU, Institut de Recherche sur les Lois Fondamentales de l'Univers du CEA, Saclay.
- LAL, Laboratoire de l'Accélérateur Linéaire (CNRSlUniversité Paris-Sud,), Orsay.
- LERMA, Laboratoire d'Etude du Rayonnement et de la Matière en Astrophysique (Observatoire de ParislCNRSlENSlUniversité Cergy-PontoiselUPMC), Paris.
- LPSC, Laboratoire de Physique Subatomique et de Cosmologie (Université Joseph-FourierlCNRSlGrenoble-INP), Grenoble.
- CC-IN2P3, CNRS's National Institute of Nuclear and Particle Physics Computing Center.

To find out more

- You can find out more about the Planck mission at http://public.planck.fr/
- In 2015, CNES will launch a giant stratospheric balloon carrying an experimental array weighing around one tonne to an altitude of 40 km. The experiment was developed by CNRS, CEA and CNES, with contributions from the Universities of Rome and Cardiff. The experiment, called PILOT, will map the polarized emission from the disc of our Galaxy in even greater detail (approximately one twentieth of a degree) and at a wavelength complementary to those measured by Planck.
More information is available at: http://pilot.irap.omp.eu/PAGE_PILOT/index.html

Sources

The four papers, whose authors are members of the Planck collaboration, have been submitted to *Astronomy & Astrophysics*:

- Planck intermediate results. XIX. An overview of the polarized thermal emission from Galactic dust : http://arxiv.org/abs/1405.0871
- Planck intermediate results. XX. Comparison of polarized thermal emission from Galactic dust with simulations of MHD turbulence : http://arxiv.org/abs/1405.0872
- Planck intermediate results. XXI. Comparison of polarized thermal emission from Galactic dust at 353 GHz : http://arxiv.org/abs/1405.0873
- Planck intermediate results. XXII. Frequency dependence of thermal emission from Galactic dust in intensity and polarization : http://arxiv.org/abs/1405.0874

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