ATOMIC AND MOLECULAR PHYSICS

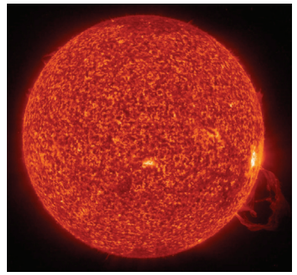
JPL scientists in atomic and molecular physics engage in laboratory experiments that explore new phenomena and provide basic atomic collision data for understanding solar and stellar plasmas as well as interstellar and interplanetary regions. We perform experiments using fast hydrogen and oxygen atom collisions with grain-adsorbed molecules to form polyatomic molecules — the building blocks of life. We are also developing state-of-the-art miniature mass spectrometer systems for planetary exploration and for monitoring astronaut air quality for the human spaceflight program. A miniaturized mass spectrometer system, the Trace Gas Analyzer, will be reflown on the International Space Station (ISS), and a miniaturized gas chromatograph/mass spectrometer system, the Vehicle Cabin Atmosphere Monitor, will also be deployed on the ISS.

RESEARCH AREAS

- Measuring the excitation cross sections of highly-charged ions (HCIs)
- Measuring charge-exchange cross sections for coronal equilibrium; measuring lifetimes of metastable HCI levels
- Measuring polyatomic molecule formation on interstellar grain analogs
- Developing miniature mass spectrometer systems based on the Paul ion trap
- Simulating ion trajectories in Paul traps using the JPL supercomputer

SPACE PHYSICS AND HELIOPHYSICS

Research in space physics and heliophysics at JPL spans a wide range of topics, including the study of the tenuous plasmas that fill interplanetary space, the violent upheavals on the Sun that drive solar flares and coronal mass ejections, and the plasma environments of the Earth and planets and their interactions with the solar wind. Heliophysics encompasses all the processes involved in the interactions between the Sun and the other solar system bodies and with the surrounding interstellar medium. JPL scientists are involved in space missions including the joint ESA–NASA Cassini and Cluster missions, and the NASA missions Solar Terrestrial Relations Observatory (STEREO) and Juno. JPL research focus includes theoretical plasma physics, the development of instrumentation, and the analysis and interpretation of data.



A prominence eruption on the Sun captured in ultraviolet light by one of the twin spacecraft of NASA's STEREO mission.

RESEARCH AREAS

- Investigating the physics of the solar photosphere, chromosphere, and corona
- Modeling solar wind acceleration and heating
- Measuring and analyzing the structure and dynamics of the heliospheric magnetic field
- Exploring planetary magnetic fields and magnetospheres
- Studying physical processes in the aurora and ionosphere
- Studying the effects of solar variability on climate

RELATIVISTIC ASTROPHYSICS

Research on relativistic astrophysics at JPL is principally concerned with the emerging field of gravitational-wave astronomy. JPL scientists are quite active in the Laser Interferometer Space Antenna (LISA) project, a planned satellite mission to detect gravitational waves from space. Gravitational waves, which are ripples in the fabric of spacetime, are emitted by accelerating masses, such as two stars in a binary system. LISA will detect gravitational waves from thousands of short-period white-dwarf binaries in our own galaxy, as well as from mergers of million-solar-mass black holes throughout the Universe. We are also involved in current and planned solar system tests of General Relativity (Einstein's theory of gravitation), such as laser ranging to the Moon and Mars.

RESEARCH AREAS

- Investigating the astrophysics of gravitational-wave sources
- Developing techniques for gravitational-wave data analysis
- Studying gamma-ray sources, using Earth occultations
- Testing General Relativity via lunar laser ranging
- Developing new satellite tests of General Relativity

Two supermassive black holes emitting radio jets in 3C 75, at a distance of 300 million light-years. When pairs of supermassive black holes eventually merge, they emit a phenomenally powerful burst of gravitational waves that would be detectable by LISA.

CONTACT US

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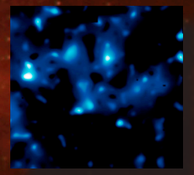
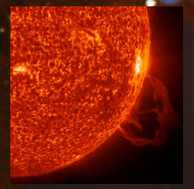
National Aeronautics and Space Administration

JET PROPULSION LABORATORY

Astrophysics and Space Sciences





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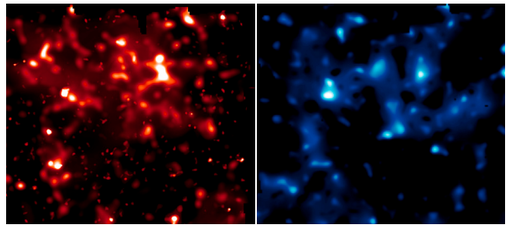
Astrophysics and Space Sciences research at JPL covers a broad spectrum of topics including the Sun, the formation of stars and planetary systems, the evolution of galaxies, and the structure and evolution of the Universe. Our scientists engage in theoretical studies, data analysis, and advanced instrument development, all generally focused on existing or future NASA missions. A world of possibilities awaits you at JPL. As a scientist here, you'll have opportunities for research not possible anywhere else.

COSMOLOGY

"Where did we come from? What powered the Big Bang? What is the nature of dark matter and dark energy?" These are among the deepest questions faced by astronomers and cosmologists today. Cosmologists at JPL are leading efforts to develop the advanced technologies and sophisticated techniques to directly address these questions. We develop new detector technology, instruments, and concepts, providing new capabilities for sensitive photometric, polarimetric, and spectroscopic observations. In addition, we develop the analysis tools necessary to study a rich and diverse set of astrophysical data. These data are acquired with telescopes located in Antarctica, the Atacama Desert of Chile and Mauna Kea volcano on the big island of Hawaii, and NASA spaceborne observatories, including Hubble and Spitzer. JPL developed instrumentation for the European Space Agency (ESA)–NASA Planck and Herschel missions, and we are now involved in analysis of data from these missions, which launched in 2009.

RESEARCH AREAS

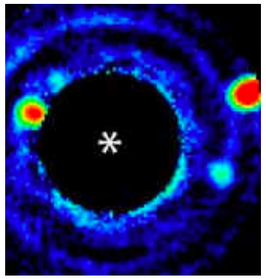
- Developing cryogenic detectors and instrumentation for studies of the polarization anisotropy of the Cosmic Microwave Background (CMB)
- Analyzing CMB data to reveal the early history of the Universe
- Developing techniques for studying the distribution of dark matter using gravitational lensing



Comparison of maps of visible and dark matter. The maps were created using the technique of weak gravitational lensing. Only about 20% of the matter in the Universe is visible.

ORIGINS OF STARS AND PLANETS

JPL scientists who study the origins of stars and planets are using telescopes and advanced models to study the formation and death of stars and the physical and chemical processes in the spinning clouds of gas and dust where these stars are born. We also develop techniques, instruments, and mission concepts for the direct detection, imaging, and characterization of exoplanets — planets orbiting the nearby stars in our galaxy. We use these same techniques to image and study the planet-forming disks around stars. We are heavily involved in developing missions to find and image exoplanets, such as the Space Interferometry Mission (SIM) and Terrestrial Planet Finder (TPF).



Simulated image of a nearby planetary system, as would be taken using an advanced coronagraph demonstrated at JPL. The white asterisk denotes the position of the central star, whose light has been blocked using the coronagraph.

RESEARCH AREAS

- Developing high-contrast imaging technologies for future space telescope mission concepts such as TPF
- Studying planet formation in the circumstellar disks of young stars from ground and space observatories
- Characterizing the atmospheres of Jupiter-class planets around other stars using spectroscopic observations from ground-based and space telescopes
- Observing and analyzing outflows from young stars and dying stars

STRUCTURE AND EVOLUTION OF GALAXIES

Galactic structure and evolution researchers study whole galaxies as coherent, self-contained systems of dark matter, stars, and gas, changing over billions of years of time. The history of a galaxy is shaped by its internal processes (star formation and death, gravitational interactions among its components, and sometimes by an active black hole engine at its core) and by interactions with its environment (other galaxies and the Universe itself). Current active areas of research at JPL employ radio, infrared, optical, and X-ray observations using space missions such as NASA's Spitzer Space Telescope, Wide-Field Infrared Survey Explorer (WISE), Nuclear Spectroscopic Telescope Array (NuSTAR), and the ESA–NASA Herschel mission.

RESEARCH AREAS

- Mapping star-forming molecular clouds using submillimeter astronomy
- Modeling the gas and dust in debris disks around protostars
- Studying the formation and evolution of galaxies in the early Universe using infrared observations
- Modeling relativistic jet outflows ejected by black holes in active galaxies and quasars
- Developing instrumentation for NASA missions such as the Mid-Infrared Instrument (MIRI) on the James Webb Space Telescope (JWST), and for the Deep Space Network and the Square Kilometer Array (SKA).
- Developing science observing plans for Herschel, WISE, NuSTAR, and SIM.

The Messier 51 interacting galaxy system. This image combines data from several of NASA's Great Observatories.

Explore the Possibilities