Max Planck institut

Max Karl Ernst Ludwig Planck, (23.4.1858 – 4.10.1947) was a German theoretical physicist who originated quantum theory, which won him the Nobel Prize in Physics in 1918.

Planck made many contributions to theoretical physics, but his fame as a physicist rests primarily on his role as an originator of the quantum theory. **Max Planck's quantum theory** revolutionized human understanding of atomic and subatomic processes, just as Albert Einstein's theory of relativity revolutionized the understanding of space and time. Together they constitute the fundamental theories of 20th-century physics. However, his name is also known through the re-naming in 1948 of the German scientific institution, the Kaiser Wilhelm Society as the **Max Planck Society** (MPS). The MPS now includes 83 institutions of scientific specialties, such as the Max Planck Institute for **Extraterrestrial Physics.**

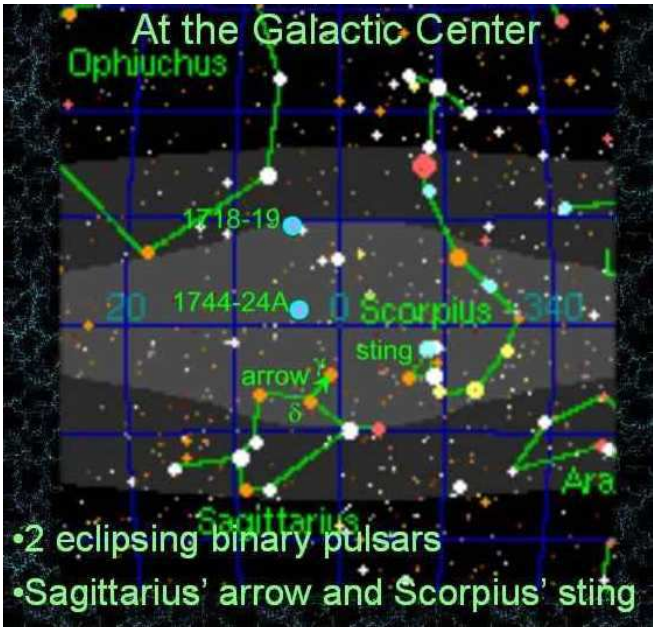
In the front line of contemporary astronomical research is the **Max Planck Institute for Extraterrestrial Physics (MPE)** in Garching near Munich, Germany. Founded in 1963, it today occupies a key international , position in astrophysics and plasma research. The institute is part of the largest concentration of outstanding astrophysical research capabilities in Europe.

Situated next to MPE, and working in close collaboration with it, are the European Southern Observatory **(ESO),** the Max Planck Institute for Astrophysics **(MPA),** and the Excellence Cluster "Origin and Structure of the Universe". Together with the Technical University of Munich, the Max Planck Institute for Plasmaphysics (IPP), and the Max Planck Institute for Quantum Optics (MPQ), the Garching campus represents one of the largest science centres of the world.

SCIENCE in MPA: Into the Very Centre – Galaxies, Galactic Nuclei and Supermassive Black Holes Galaxies, beautiful and spectacular islands of stars and gas, are the building blocks of the visible Universe. Each galaxy is unique, and its morphology, size and mass all give us clues about how it has developed and evolved from the times when the Universe was in its infancy to the present day.

Our Milky Way, for example, is a large spiral galaxy with about 200 billion stars, our Sun being one of its more average members. **MPE scientists study** the properties, activity and evolution of galaxies across the entire electromagnetic spectrum, both in the local and in the distant Universe telling us about the past. One of the most remarkable findings of the last decade is that nearly all big galaxies contain a massive **Black Hole.** When such Black Holes accrete new material their host galaxies become active. The most luminous and spectacular of these active galaxies are quasars. Much of our research at MPE, therefore, focuses on the central regions of galaxies, where these supermassive Black Holes (with millions to billions solar masses) reside. In the future, our studies of the Black Hole in the Milky Way will allow tests of various predictions of **general relativity**, such as the hypothesis that Black Holes bend space. The interaction of the Black Hole with its immediate environment is also important: How do accretion disks and jets in active galactic nuclei form and with which physical laws do they comply? How does the Black Hole influence the surrounding stars? Also, we study the interaction of the Black Hole with the galaxy as a whole.

The Galactic Centre – a unique Laboratory The closest galactic nucleus is the one in the Galactic Centre, the centre of our Milky Way, at a distance of "only" 25 000 light years.



Its relative proximity affords the opportunity to study the detailed physical processes at play in the environs of a supermassive Black Hole. Research at MPE has centred on proving the existence of the Black Hole, and then deriving its properties. Since 1992, we regularly observed the Galactic Centre in the near-infrared with high spatial resolution instruments that we helped design and build for ESO telescopes. By measuring the positions of stars close to the Galactic Centre with extremely high accuracy, we determined that they move along Keplerian orbits around a central mass of about four million times the mass of our Sun. The innermost star comes as close as 18 light hours – about four times the orbital radius of the planet Neptune arend the Sun – to this central mass. A Black Hole is the only viable explanation for such a high mass density! We were also able to observe near-infrared flares from this central region, which exhibit a quasiperiodic behaviour with a period of about 17 minutes. Our observations suggest that the Black Hole rotates with a significant spin.

Currently we are developing GRAVITY, a new instrument for the interferometer of ESO's Very Large Telescope (VLT), that will combine the light from the four 8-metre telescopes. This instrument will enable us to make measurements with dramatically improved angular resolution, thus making it possible to image the Black Hole and look down to its event horizon.

Active Galactic Nuclei – Monsters in Space

When massive Black Holes at the cores of galaxies become active, they can become very luminous indeed. Some even become a trillion times more luminous than our Sun! The incredible process responsible for this activity is the supermassive Black Hole "feeding" on matter in its environs. Once this happens, these objects radiate a measurable amount of energy across the entire electromagnetic spectrum, from radio up to gamma-ray energies. The energetic trigger of these active galactic nuclei is the strong gravitational force of supermassive Black Holes. However, many phenomena, such as the plasma jets expelled nearly with the speed of light, are still a mystery. At MPE we try to understand them by contributing to and using the currently operating, high-energy satellite missions, such as Chandra, XMM-Newton, and the Fermi Gamma-ray Space Telescope.

The centres of galaxies are often hidden behind thick swathes of dust that block our view. Space satellites such as Spitzer and Herschel observe at Langer infrared wavelengths that can penetrate this dust. Peering into the heart of the active nucleus, we can discern the role that different processes play in producing the radiation. Complementing this, ground based observatories equipped with adaptive optics systems, such as SINFONI at the VLT telescopes, can correct for the blurring from the atmosphere to reveal the nuclei in exquisite detail. Using these observations, we can study the interplay between the gas and stars, and understand how these influence the rate at which the Black Hole is fuelled. By measuring the motions of the stars we are able to weigh the Black Holes, an important step in understanding how Black Hole and host galaxy grow and evolve together.

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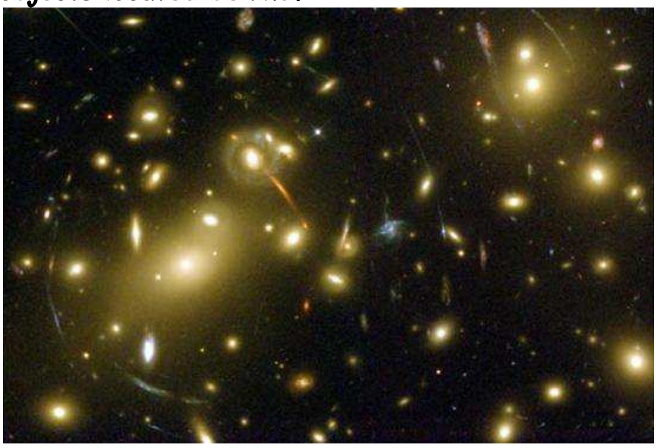
Shaping the Universe – Dark Matter and Dark Energy

Astronomers know that stars in galaxies and individual galaxies in clusters are moving much too fast for their visible mass to hold them together.

Since celestial motions are governed by gravity, and gravity is caused by matter, there must be a large amount of additional, invisible matter - so called "Dark Matter". We estimate that there is about five times more dark than visible matter, making Dark Matter a key player in shaping our Universe. Non-luminous celestial objects such as planets cannot account for all the missing mass, other candidates such as weakly interacting, exotic particles, however, have yet to be observed. MPE is actively investigating Dark Matter by measuring its mass and mass distribution in galaxies and galaxy clusters. One important method is the so-called "gravitational lensing effect", by which a light ray is deflected by a massive object such as a galaxy or galaxy cluster. The distorted image or even multiple images of background objects allow us to calculate the total mass of the lensing object, and to determine its Dark Matter content. Dark Matter is not distributed uniformly in the Universe but rather along filaments. The luminous matter, stars and galaxies, follow the Dark Matter distribution. In nearby galaxies we trace the motion of stars to derive the structure of their Dark Matter halos. In our own Milky Way we can use the gravitational lensing effect, searching for the temporary brightening of objects towards our large neighbouring **galaxy Andromeda**, to detect non-luminous celestial objects and to estimate their mass fraction.

The massive galaxy cluster Abell 2218 acts like a gravitational telescope and bends the light of objects located behind.



About fifteen years ago, detailed measurements on far-away supernova explosions were carried out to observe and quantify how the expansion of our Universe slows down. Very surprisingly however, the astronomers discovered that the Universe now expands with increasing velocity. An unknown phenomenon, called Dark Energy, is counteracting gravity and so accelerates the expansion of our Universe. MPE scientists aim to determine the equation of state, pressure and density, of the Dark Energy as a function of time. For this the astronomers have to understand how the Universe has expanded since the Big Bang. Acoustic waves, stimulated by quantum fluctuations, imprinted a wave pattern in the density of the primordial plasma. Since slightly more galaxies formed in (overdense) wave crests than in (underdense) wave troughs, measurements of the spatial distribution of galaxies as a function of distance reveal the expansion history of the Universe and the influence of Dark Energy. To measure this spatial distribution, MPE actively participates in several galaxy surveys conducted on large telescopes. For example, the HETDEX survey will accurately collect the position and redshift (i.e. distance) of millions of galaxies. MPE scientists design and write the software to analyse such huge datasets to extract their information on **Dark Energy** and to unravel its mysteries.

History - Historie – historky…

Brand der Baracke während der Weihnachtsfeier 1970

Während der Weihnachtsfeier am 22.12.1970 brannte die Baracke (Laborbaracke) der Sonnenwind-Gruppe vollständig ab. Neben der Vernichtung von Teilen und wichtigen Unterlagen der Satelliten HEOS, HELIOS, Pioneer F und G und Grand Tour wurden auch einige Doktorarbeiten ein Raub der Flammen.
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Complex Plasma – a new State of Matter

The three well-known forms of matter are solid, liquid, and gas. However, 99 percent of visible matter in the Universe is in the state of plasma, a fourth form. Plasma is formed when gas is heated to the point that it breaks down into its ion and electron constituents. These four forms of matter can been viewed as analogous to the old elements of earth, water, air, and fire. Plasma is everywhere, although it often goes unrecognized. The mammoth strike of a lightning bolt and the tiny sparks of static elektricity are both examples of plasma. The Sun is a huge ball of plasma; in fact, plasma is quite common in space. On Earth, plasmas have multiple uses in many industrial applications from lights to plasma televisions. A plasma is regarded as the most disordered state of matter. So it came as a major surprise when in 1994, MPE scientists discovered that under special conditions plasmas can become liquids, and may even spontaneously crystallise. These special plasmas are called "Complex Plasmas". A complex plasma, compared to an ordinary plasma, has an additional component – **charged supramolecular microparticles.** Although these microparticles can be as small as one thousandth of a millimetre, they are extremely heavy – many billions of times heavier than an atom – and carry thousands of electron charges. In fact, if their number is sufficiently large, they become the dominant dynamical component and can even determine the structure of the plasma.

SLOVNÍČEK

evropský sociální fond v ČR
EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

EXKURZE FYZIKÁLNĚ CHEMICKÉHO SEMINÁŘE
4.-7.11.2014

Plán exkurzí:

úterý 4.11.:
Max Planck Institut für Extraterrestrische Physik – Garching
-prohlídka komentovaná anglicky – na co si vzpomenout? Co víte z astrofyziky?

středa 5.11.:
CERN – exkurze
-prohlídka komentovaná anglicky – co víte o mikrosvětě, jaderné fyzice, elementárních částicích,…?
V areálu výstavy *Microcosm* a *Universe of Particles*

Projekt je spolufinancován z prostředků ESF a státního rozpočtu ČR