Almost half of the visible matter in the Universe is in the form of the hot gas at the temperature of millions of degrees. Such matter is a source of invisible X-ray radiation and it can be exterminated only with the use of special detectors. The first X-ray observations proved that the hot matter is locked in the centers of galaxy clusters, it surrounds galaxies and their active nuclei, and it is located in the vicinity of black holes, the best example is the one in our Galaxy -SgrA*. Hot intergalactic gas, commonly known as WHIM (Warm Hot Intergalactic Medium) is an essential part of matter, but we do not know how it was created. Most of such gas is outflowing from the centers of galaxies in the form of hot, ionized wind, which nature is not fully understood. The key question is how does the hot matter assemble into the large scale structure we see today and how does it shape the Universe.
Active Galactic Nuclei (AGN) and galactic binary systems are the strongest X-ray emitters.
These objects have accretion disks, in which matter falls onto the central mass due to the strong gravitational field. The accreting matter very often is heated to millions of degrees forming a kind of corona above the accretion disk. However, the researchers do not fully understand the mechanism of heating such corona, as in the case of our Sun. To understand the hot gas distribution in the strong gravitational field is crucial for understanding the evolution of active galaxies and the black hole growth.

The exploration of the Universe in X-ray band is the most expensive branch of modern astrophysic.
Photons at energies from the range between 0.1 to 100 keV are completely absorbed by the Earth's atmosphere. Therefore, to see the Universe in X-rays we need to build a telescope satellite and launch it into the space. For this reason, X-ray astronomy had developed in the second half of the XX century, when we have learned to launch satellites above the atmosphere. Approximately 15 years period time is needed for full construction of the flight telescope from the mission concept up to the launch.
With the current technology, the best detection we achieve for photons from the narrow energy range from 0.1 to 10 keV. For those photons we can measure their energy, the direction and the moment of arrival.
On Nov. 2013, the new generation X-ray telescope ATHENA (the Advanced Telescope for High Energy Astrophysics) was approved by European Space Agency as a second large mission, with a launch foreseen in 2028. ATHENA telescope will be equipped with the most modern X-ray mirrors inclined in such a way that X-ray photons are grazing over their surface. Additionaly, those mirrors will posses many microscopic pores, which help to focus X-ray radiation. Polish scientists and research engineers are participating in the design and construction of the telescope.
ATHENA will be equiped with two focal plane detectors, which will be used alternatively depending on the observational plan. X-IFU (X-ray Integral Field Unit) is a very innovative detector, in which a single pixel measures extremely small temperature difference caused by X-ray photon that enters into it. The photon energy will be measured with very high precision, as never achived before. The second detector, WFI (Wide Field Imager) will be built with conventional silicon pixels, but with modern rapid signal readout electronics. The above combination of instruments allows us to formulate research tasks which, according to experts of the European Space Agency, are the most important from the point of view of modern astrophysics.

The X-ray observations provide us information about the temperature, density and mass of hot gas in a given area of ?? the sky. Sometimes it is possible to determine the velocity of the emitting gas. These physical parameters combined with the time of observation provide basic information about the morphology and evolution of the observed objects, and thus their connection with colder gas seen in visual light.
ATHENA will provide us the information about the dynamics and the distribution of hot matter in the Universe. Thanks to them we will understand how how does the hot gas stabilize clusters of galaxies, and how do the supermassive black holes grow. With the ATHENA telescope, we will investigate
the process of matter falling onto supermassive black hole, in particular its relation with outflowing hot winds (galaxy feedback).
X-rays are short enough to produce emission or absorption lines from ionized heavy elements, when they interact with matter. Observations of those lines allow us precisely examine heavy elements content and their chemical evolution in astrophysical objects.
Beside more distant objects, ATHENA will be suitable to search for objects from our Galaxy as X-ray binary systems and their outflows, coronae of hot stars, and our Galactic Center – Sgr A*.

The aim of this project is to study the mechanisms of formation and distribution of the hot gas in the context of different astrophysical objects. We're going to count how many of warm baryons are in the local Universe. We will examine the distribution and stability of the hot gas in the center of our Galaxy, in particular, we will check whether the result obtained by us can be applied to other galaxies.
We plan to compute models of X-ray emission from ionized wind, illuminated accretion disks, and hot neutron star atmospheres. We will develop a new model of magnetically-heated corona above an accretion disk. All theories formulated by us will be used to interpret future results of the ATHENA mission.
For many years, Polish engineers build different satellite components. They were invited to participate in the design of WFI/ATHENA detector by researchers from Max Planck Institute. Such activities are one of the most important criteria for further sharing of observation time and specification of the objects to be observed. Polish participation depends primarily on the development of theoretical models and tools for data analysis, which will be used after the launch of the satellite. This project aims to consolidate all activities done by our group for better understanding of the hot Universe.