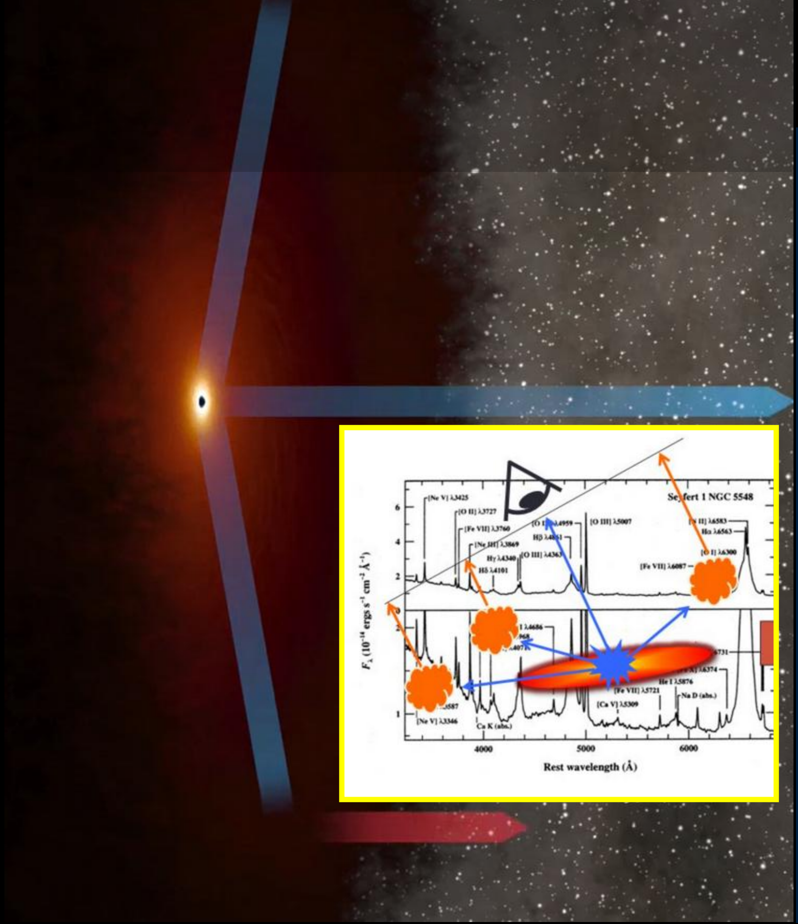
The Hunt for obscured AGNs in the current X-ray surveys

Supervision: *Angelos Nersesian, Maarten Baes*

The typical spectral energy distribution (SED) of an active galactic nucleus (AGN) covers a broad wavelength range, from X-ray to infrared (IR), and is generated by different physical processes. Although X-ray surveys provide a reliable detection-method for obscured AGNs, many of the most highly obscured AGNs will be missed, restricting our census of the overall AGN population. Multi-wavelength observations could allow the identification of X-ray undetected AGNs that produce luminous emission at other wavelengths (e.g., at infrared, and optical wavelengths), when the contaminating emission from the host galaxy is reliably accounted for using SED decomposition. The goal of this project is to model AGN SEDs from X-ray to IR simultaneously and self-consistently with CIGALE, and decouple the AGN luminosity from the host galaxy in search of obscured AGNs.

Supervision: *Bert Vander Meulen, Maarten Baes*

Black hole reverberations in AGN



Active galactic nuclei (AGN) are the luminous centre regions of massive galaxies, powered by the accretion of gas and dust onto a supermassive black hole (SMBH). Close to the central black hole, fast-moving clouds of dense gas are illuminated by the bright accretion disk and absorb part of the accretion disk's continuum light. As these gas clouds re-emit the absorbed energy, they produce the broad emission lines observed in AGN spectra. One can map the structure of this broad-line region (BLR) by analyzing the “reverberations” in AGN: When the brightness of the accretion disk varies, the broad emission lines (excited by the accretion disk) will vary in response. However, this emission-line response is delayed with respect to changes in the continuum, corresponding to the light travel time towards the BLR. The goal of this thesis project is to extend the SKIRT code and build a toy-model to study reverberation mapping, form factors and SMBH mass determination in AGN.

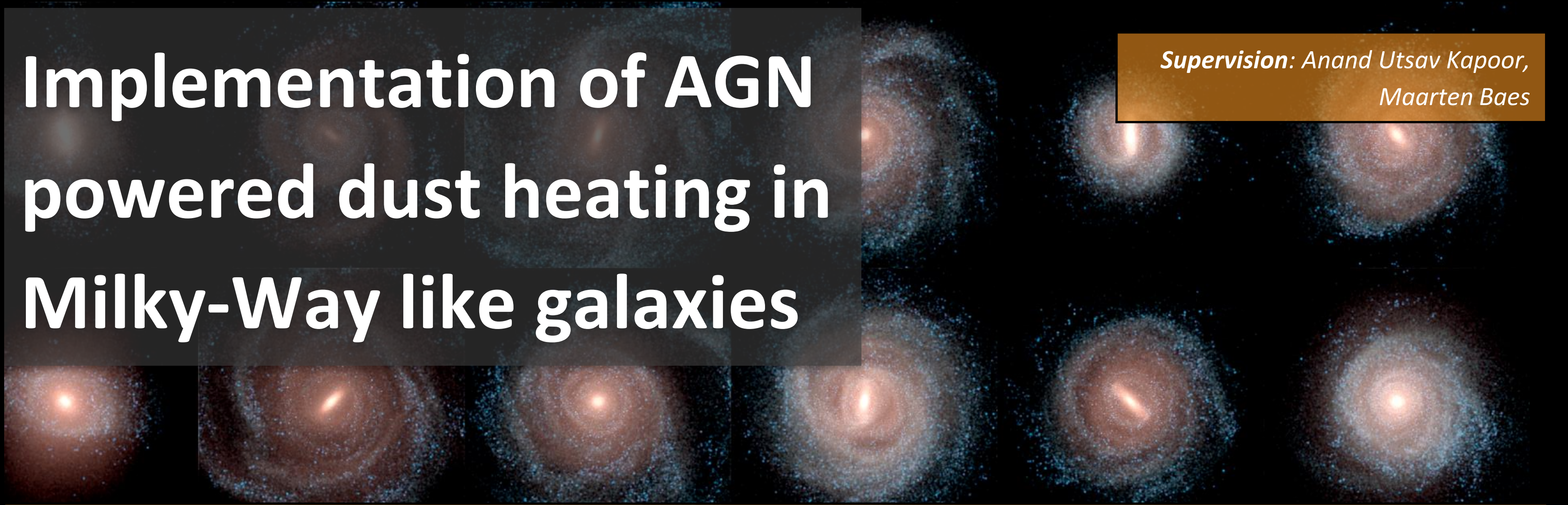
Investigating attenuation in high-resolution simulated galaxies

***Supervision**: Daniela Barrientos, Maarten Baes*

The interaction between starlight and dust in a galaxy can be simulated using radiative transfer. However, when inferring properties of observed galaxies from integrated fluxes, this interaction is often (over)simplified into an effective screen of dust between the galaxy and the observer. This avoids the cost of having to make a complete self-consistent 3D model of the galaxy, but it might lead to biases. The goal of this thesis is to investigate this dust screen assumption using high-resolution simulated galaxies from the Auriga hydrodynamical simulation. Should young stars be attenuated more than older stars? How does this depend on our viewing angle? By answering these questions, we can correct for biases in the dust screen assumption.

Implementation of AGN powered dust heating in Milky-Way like galaxies

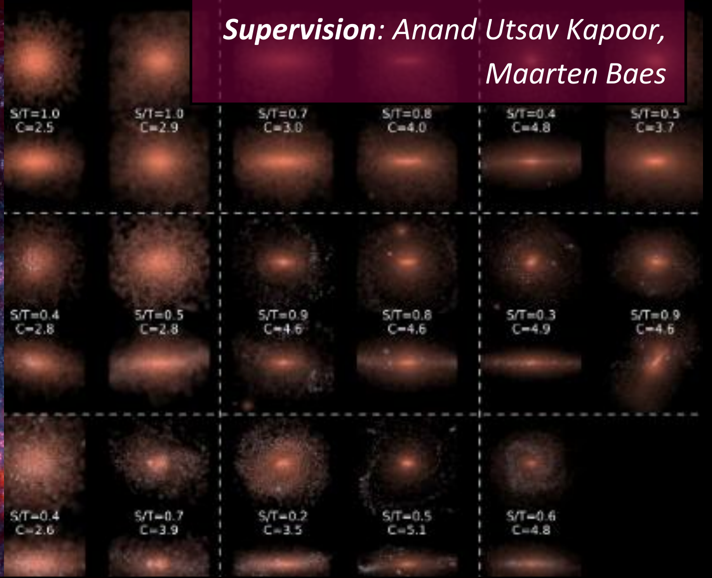
Supervision: *Anand Utsav Kapoor, Maarten Baes*



Cosmological simulations have been shown to reproduce a wide range of present-day observables of disc dominated galaxies. Post-processing procedures cater a range of astrophysical applications, including the generation of high resolution UV-submm synthetic images, delineating the impact of interstellar dust on stellar kinematics and the generation of dust polarization maps for Milky way like galaxies, to name a few. The common denominator among these applications is that we model the complex interplay of radiation and dust using the Monte-Carlo radiative transfer code **SKIRT**. So far, in the **Auriga** simulations the young and old stellar populations are included as the main dust heating sources. In this project, we want to implement an additional heating source by constructing a sub-grid model for the AGN in the simulated galaxies. We could then explore the impact of the AGN driven dust heating and its effects on galaxy physical properties.

Panchromatic morphological comparison of Milky-Way like galaxies from cosmological simulations

***Supervision**: Anand Utsav Kapoor, Maarten Baes*



The spatial resolution of cosmological hydrodynamic simulations has been steadily increasing over the past few years, allowing for a precise analysis between the observed morphology and the underlying physical processes of galaxies. Determining the structural characteristics of galaxies is essential to understand how they form and evolve. This project would involve the selection of Milky-Way like galaxies from two simulation projects (Auriga & Illustris-TNG), followed by a post-processing procedure of multiple simulation snapshots across cosmic time. The main goal is to elucidate the difference in the physics models employed in the two simulation sets, by means of a multi-wavelength morphological comparison at various cosmic epochs. The morphological comparison could be done, for example using a package like StatMorph.

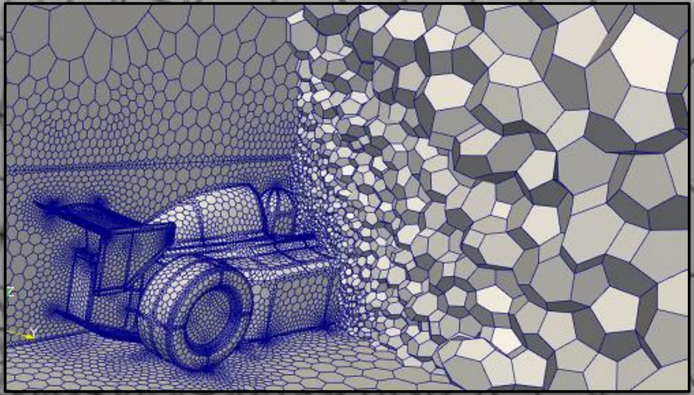
Destruction of cosmic dust by energetic radiation

Supervision: *Peter Camps, Maarten Baes*

The radiation field in astrophysical systems is substantially affected by the presence of interstellar dust. Vice versa, the dust grains may be destroyed by energetic radiation from nearby sources such as young stars or an active galactic nucleus (AGN). The goal of this project is to construct a model for dust grain destruction (depending on the properties of the local radiation field and of the dust grains), include this model in our SKIRT radiative transfer code, and evaluate the effects on the synthetic observations produced by the simulations.

Radiative transfer on an unstructured tetrahedron grid

***Supervision**: Peter Camps, Maarten Baes*



To model the interaction between radiation and matter astronomers mostly use Monte Carlo radiative transfer codes. These codes follow a gigantic number of photons individually through the system under study, which is subdivided into tiny cells. Usually a regular or an octree grid is used, but in some cases unstructured grids are more appropriate. The goal of this master thesis project is to investigate how photons can propagate efficiently through tetrahedron grids, i.e. grids in which all individual cells are tetrahedra, and explore the advantages and disadvantages of such grids for radiative transfer simulations.

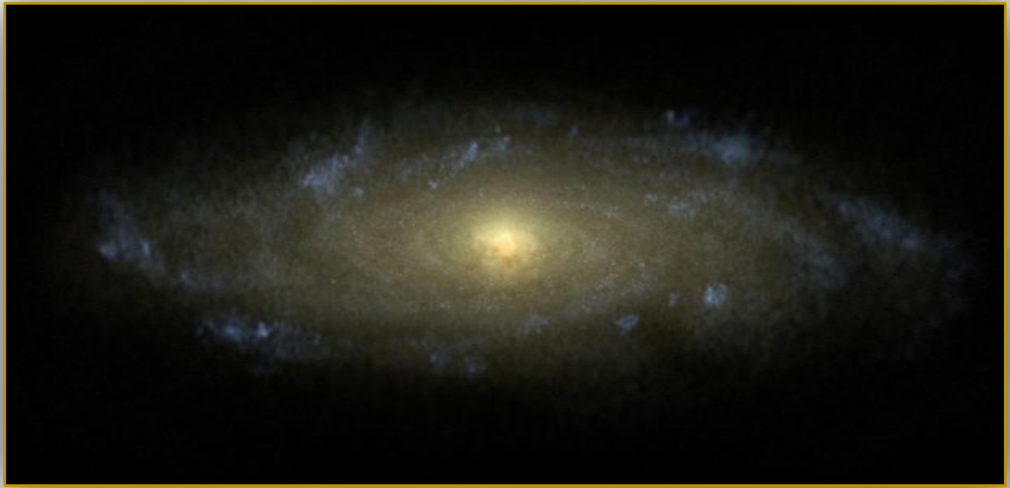
Stochastic heating of interstellar dust

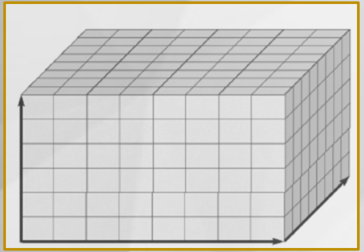
***Supervision**: Peter Camps, Maarten Baes*

A small interstellar dust grain is often not in equilibrium with the surrounding radiation field. The absorption of an energetic photon boosts the internal energy, after which the grain cools down by emitting infrared radiation. To calculate the emission spectrum of the grain, we must determine its temperature probability distribution. Radiative transfer codes routinely use an approximative method for performance reasons. The goal of this project is to implement an exact but much less efficient calculation and to evaluate in which situations the approximative method produces acceptable results, and where it does not.

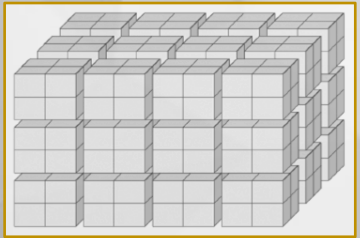
Domain decomposition in radiative transfer simulations

***Supervision**: Peter Camps, Maarten Baes*





Full domain



Partition into subdomains

To model the interaction between radiation and matter astronomers mostly use Monte Carlo radiative transfer codes. These codes follow a gigantic number of photons individually through the system under study. To handle a large model, we need to partition it in spatial subdomains and assign each subdomain to a different compute node of a supercomputer. In such as setup, photons must be transferred between compute nodes at each subdomain border. The goal of this project is to develop a prototype using spatial domain composition and to evaluate the related inter-node communication load for a number of typical models.

Dust evolution in cosmological simulations

Supervision*: Peter Camps, Maarten Baes*

Cosmological simulations have been instrumental in advancing our understanding of structure and galaxy formation in the Universe, but relatively little attention was given to ***dust***, one of the key components of the interstellar medium (ISM). That was the case partly due to the very complex and uncertain processes that regulate the dust life cycle in the ISM. The classic approach to modeling the dust for radiation transfer uses a simple recipe with a fixed dust-to-metal ratio. Recent galaxy simulations, however, track dust evolution in addition to everything else. The goal of this project is to compare the classic post-processing recipe to a recipe that uses the actual dust distribution predicted in the simulation. This can be done for multiple redshift snapshots to look for trends in the differences with redshift.