

# **MAGRITTE: a new multidimensional accelerated general-purpose radiative transfer code**

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# Abstract

Radiative transfer plays a key role in the dynamics, the chemistry and the energy balance of all kinds of astrophysical objects. It provides the radiative pressure to drive stellar winds, it affects the chemistry through various photoionization and photodissociation reactions, and it can very efficiently heat or cool very specific regions in the wind. Therefore it is essential in modelling these objects to properly account for all radiative processes and their interdependence. This however can be complicated by i) an intricate 3D geometrical structure shielding or exposing specific regions to radiation, ii) the scattering by dust or free electrons, and iii) the mixing in frequency space due to Doppler shifts caused by velocity gradients in the medium. The tight coupling between radiative transfer and the often very specialized and diverse dynamical and chemical models furthermore requires a modular code that can easily be integrated. To address these needs we will present MAGRITTE: a new multidimensional accelerated general-purpose radiative transfer code. MAGRITTE is especially designed to have a well scaling performance on various computer architectures. Appended with a dedicated chemistry and thermal balance module it can self-consistently calculate the temperature field, chemical abundances and level populations. Magritte is a deterministic ray-tracing code that obtains the radiation field by solving the transfer equation along a fixed set of rays originating from each grid cell. It iteratively accounts for scattering and treats the full frequency space. This allows us to self-consistently model the chemistry and energy balance in stellar winds and perform synthetic observations. We will apply MARGRITTE by post-processing snapshots of hydrodynamical wind and bowshock simulations and will present its integration in self-consistent hydro-chemical AGB

wind models.

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## **Chapter 1**

# **Introduction**

i. An introduction giving the context of the work; ii. A literature review; iii. A research question and hypothesis; iv. A section on methodology; v. A substantial piece of work towards the thesis objectives; vi. A plan and timetable for the remainder of the work; vii. A bibliography.

### **1.1 Context**

### **1.2 Project outline**

## **Chapter 2**

# **MAGRITTE: physics**

## **Chapter 3**

# **MAGRITTE: code**

### **3.1 Gridless ray-tracing**

### **3.2 Benchmarks**

### **3.3 Optimization**

## **Chapter 4**

# **MAGRITTE: applications**

### **4.1 Bow-shocks between stellar wind and the ISM**

### **4.2 Galaxies**

### **4.3 Spectral distortions in the CMB**



## **Chapter 5**

# **Conclusion**

### **5.1 Project status**

### **5.2 Future work**

## **Appendix A**

# **An Appendix About Stuff**

# **Bibliography**