ADVANCED COMPUTING

UTAustin Portugal

Multi-physics simulations in astronomy

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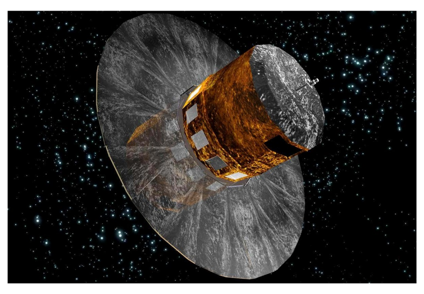
Background

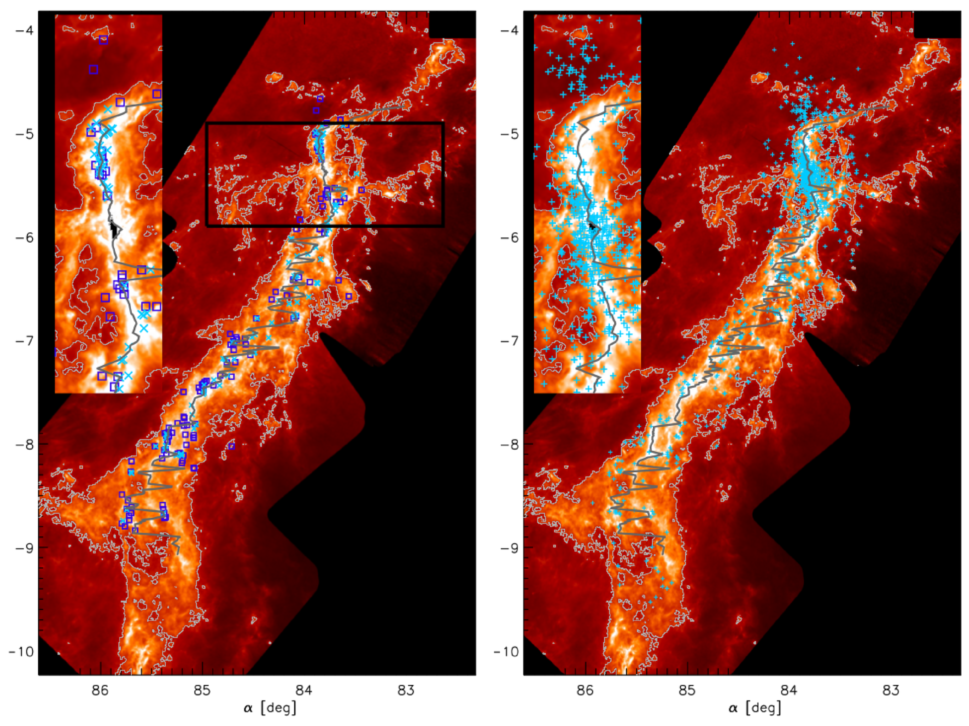
Numerical simulation has become a third pillar of science exploiting advances in computer technology for solving non-linear, multi-physics and large scale problems. In the field of astronomy, one such problem is the formation of stars. On the right, we show observations of the gas and star content in the Orion A region taken with space telescopes. We aim to understand the dynamics of these young stars and their mass function.

NASA's Spitzer space telescope



ESA's Gaia space telescope

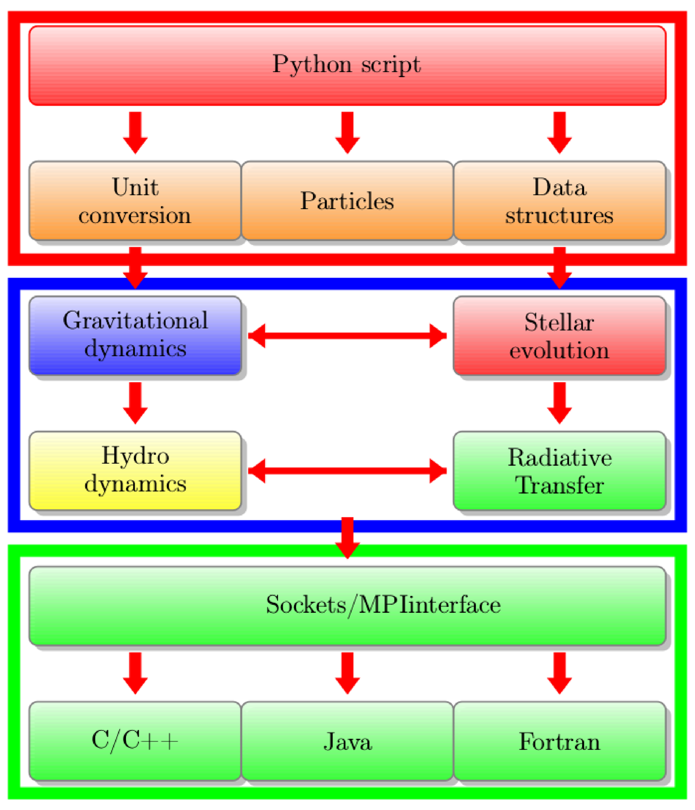
Observations of gas and stars in Orion



Taken from Stutz & Gould 2016

Methodology

In order to realistically model star formation in Orion A, we need to take into account both gravitational dynamics (stars) and hydrodynamics (gas). Coupling different physics codes is best done in a modular fashion. On the right, we show the structure of the AMUSE framework, which provides unified interfaces for each code, and parallel communication lines for exchanging data. Our main challenge is to optimize such modular frameworks on supercomputer facilities

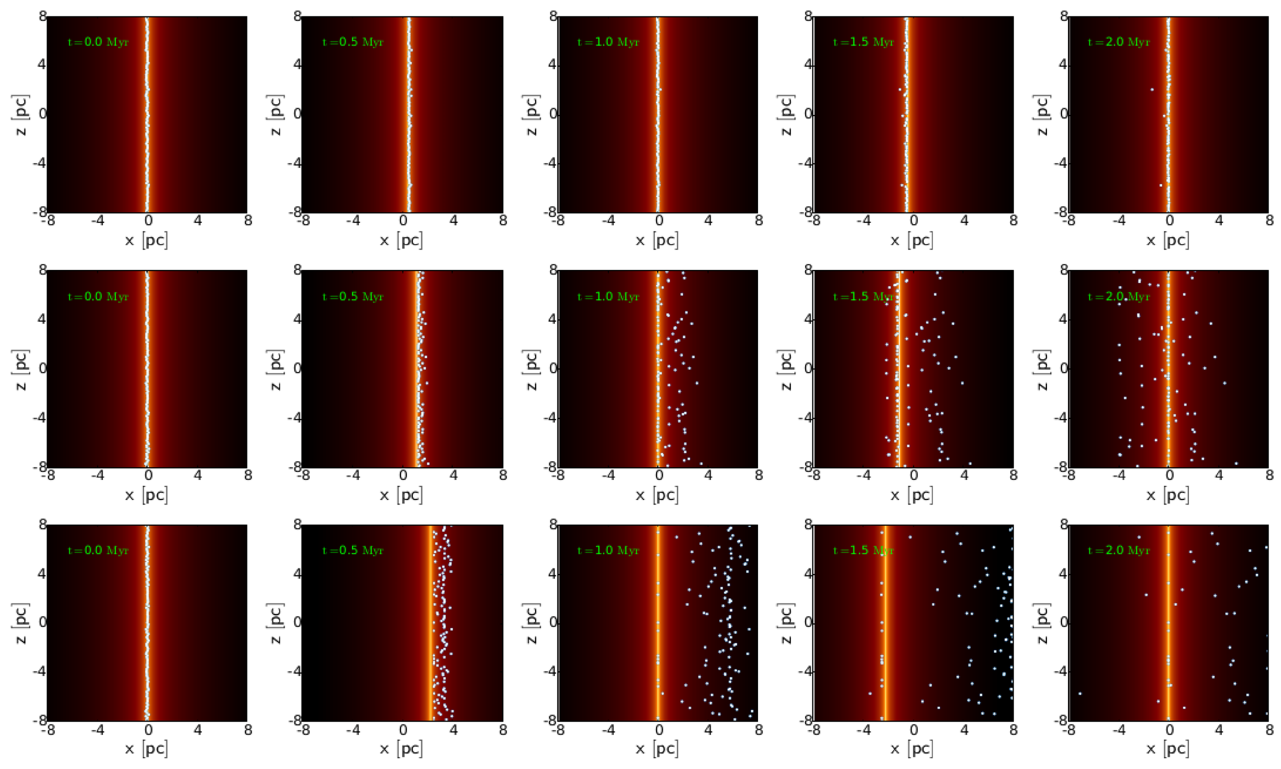


AMUSE

www.amusecode.org

Results

We performed the first simulations of the dynamical interplay between gas and stars in Orion A. We implemented a parallel N-body code, a time-dependent background potential function and a Bridge coupling method. We demonstrate that an accelerating gas filament can stir up the stellar distribution, as observed. However, we require full magneto-hydrodynamical simulations to self-consistently model the filament dynamics, which increases the physical and numerical complexity.



Boekholt et al. 2017

Conclusions

Current numerical simulations of astrophysical systems are unable to capture the level of detail in state of the art observations from space telescopes. One way forward is to implement modular software frameworks, which allow coupling of different, optimized physics codes. Our aim is to experiment with such modular frameworks, and to make them run efficiently on supercomputer hardware by performing scaling tests and design methods to minimize the communication.

This project is in collaboration with researchers from Leiden University, Netherlands, Drexel University, USA, University of Concepcion, Chile and University of Tokyo, Japan.

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FCT Fundação para a Ciência e a Tecnologia
TEXAS The University of Texas at Austin
instituto de telecomunicações
AMUSE