The cosmic evolution of discrete structures in General Relativity

ELOISA BENTIVEGNA (UNIVERSITÀ DI CATANIA) & MIKOLAJ KORZYNSKI (CFT WARSAW)

What?

Gravitational systems which are **periodic** in space, **fully relativistic**, and strongly **inhomogeneous**. They are constructed in a bottom-up approach, starting with exact compact-object solutions of General Relativity (e.g., Schwarzschild black holes), and assembling them together according to a set of rules which guarantees that the resulting spacetime is also a solution of Einstein's equation. On scales much larger than the separation between black holes, the models can be regarded as spatially homogeneous and isotropic. Closer in, the gravitational field of a single, non-linear structure prevails. **The full metric tensor bridging these two scales is known.**

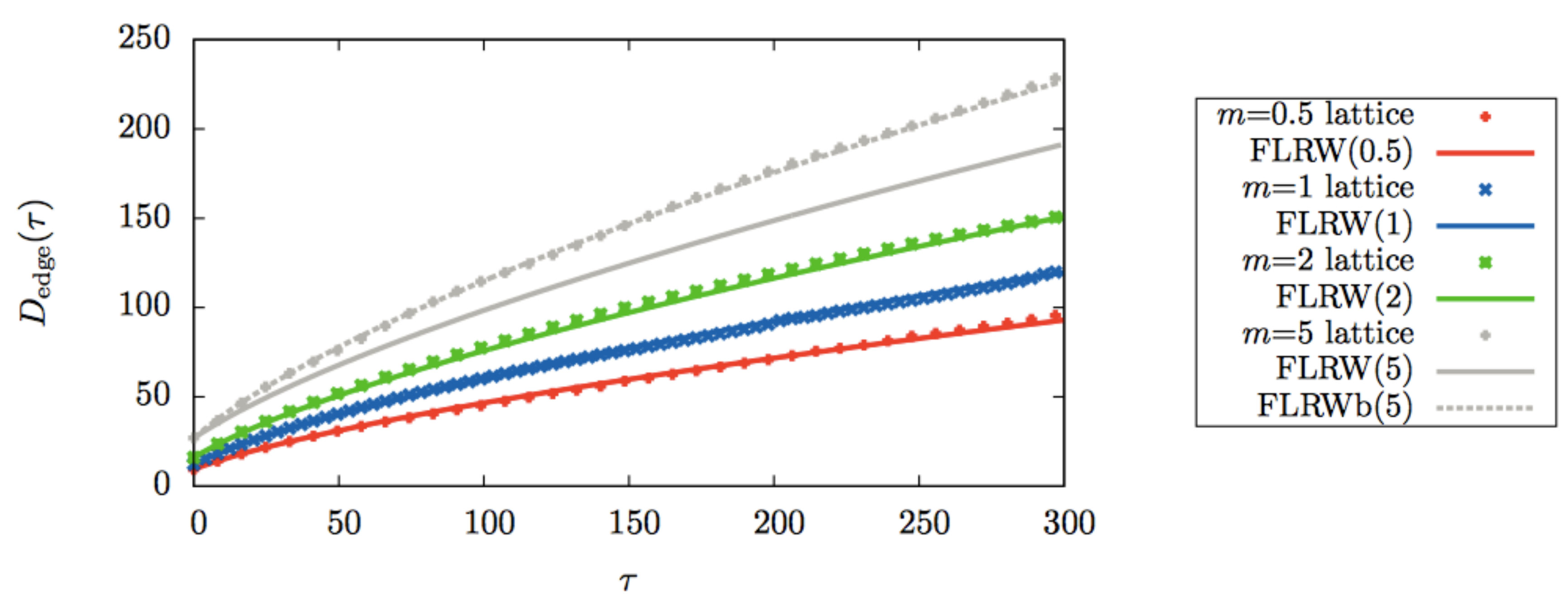
Why?

The behaviour of small groups of compact objects is well known in General Relativity; the relativistic aspects of larger systems, especially those **exhibiting large-scale homogeneity**, are much less understood. Yet, these systems are good models for the Universe, and constructing them explicitly may yield useful insight into the common traits of (and the differences between) inhomogeneous and averaged cosmologies.

How?

The construction of these generic systems is possible thanks to **Numerical Relativity**, a set of techniques and tools to integrate Einstein's equation (and any equations governing its stress-energy sources) numerically, as a set of coupled partial differential equations. Leveraging the power of supercomputers, this approach allows for the simulation of **arbitrary systems with no assumptions on spacetime symmetries or limits on the gravitational field's strength**.

The first application of this formalism to the construction of periodic structures in General Relativity is **black-hole lattices**, systems first studied under various approximations in [1, 2]. In [3, 4, 5], the complete spacetimes were generated for the first time. In all cases considered, the expansion history remains quite **close to the corresponding averaged cosmology**, even though these models are highly non-linear!



More!

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2. T. Clifton & P.G. Ferreira, *Archipelagian Cosmology: Dynamics and Observables in a Universe with Discretized Matter Content*, Phys.Rev. D80 (2009) 103503
3. E. Bentivegna & M. Korzynski, *Evolution of a periodic eight-black-hole lattice in numerical relativity*, Class. Quantum Grav. 29 (2012) 165007
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