Universidade do Minho

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Critical phenomena in gravitational collapse: working plan

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Critical phenomena in gravitational collapse using GR

Take generic initial data in general relativity, adjust a parameter p of the initial data to the threshold of black hole formation, and compare the resulting spacetimes as a function of p.

The following critical phenomena are then observed:

- Near the threshold, black holes with arbitrarily small masses can be created, and the mass scales as

$$M \propto (p - p_*)^{\gamma}$$

  where black holes form for $p > p_*$.

- The critical exponent γ is universal with respect to initial data, but it depends on the type of collapsing matter.

- In the region of large curvature before black hole formation, the spacetime approaches a self-similar – scale-invariant – solution which is also universal with respect to initial data.

Critical phenomena in gravitational collapse using GR

We propose to study:

- Critical phenomena in the collapse of dust and radiation and unify them in a single scheme
- Critical phenomena in non-spherically symmetric collapse
- Relation between critical phase transitions in gravitational collapse and renormalization groups
- Study the physical properties (e.g. Mass, entropy) of black holes' horizons and emission of gravitational waves

Critical phenomena in gravitational collapse in modified theories of gravity

We propose to study:

- Gravitational collapse in Lovelock theory

Lovelock theory is the most general, torsion-free, theory of gravity in N dimensions that yields second-order field equations for the metric.

- Gravitational collapse in Einstein-Cartan theory

Given a general connection $C^{\gamma}_{\alpha\beta}$

$$\nabla_\alpha V^\beta = \partial_\alpha V^\beta + C^\beta_{\alpha\sigma} V^\sigma$$

Christoffel Symbols: $\Gamma^\beta_{\alpha\sigma} = C^\beta_{(\alpha\sigma)}$

Torsion: $S^\beta_{\alpha\sigma} = C^\beta_{[\alpha\sigma]}$

Critical phenomena in gravitational collapse in modified theories of gravity

We propose to study:

- Gravitational collapse in brane-world gravity theory

The observable universe is considered to be a 3+1-surface (the "brane") embedded in a 3+N+1 dimensional spacetime (the "bulk"), with Standard Model particles and fields trapped on the brane while gravity is free to access the bulk.