# Spin-down phase of black hole evolution

#### **Elizabeth Winstanley**

Astro-Particle Theory and Cosmology Group, University of Sheffield, United Kingdom



## Outline

- Formation and evaporation of rotating brane black holes
- Hawking radiation during "spin-down"
  phase
- Monte-Carlo simulations of "spin-down" phase
- Conclusions

### Formation of rotating black holes



Figure taken from Frost et al, JHEP 10 (2009) 014

### Evaporation of brane black holes

Black holes formed in high-energy collisions will be rapidly rotating, highly asymmetric, and have gauge field hair



# "Spin-down" phase



$$ds^{2} = \left(1 - \frac{\mu}{\Sigma r^{n-1}}\right) dt^{2} + \frac{2a\mu\sin^{2}\vartheta}{\Sigma r^{n-1}} dt d\varphi - \frac{\Sigma}{\Delta} dr^{2} - \Sigma d\vartheta^{2}$$
$$-\left(r^{2} + a^{2} + \frac{a^{2}\mu\sin^{2}\vartheta}{\Sigma r^{n-1}}\right) d\varphi^{2} \qquad \Delta = r^{2} + a^{2} - \frac{\mu}{r^{n-1}}$$
$$\Sigma = r^{2} + a^{2}\cos^{2}\vartheta$$

#### Fluxes



# Energy fluxes



7-dimensional black hole

Figures taken from Casals et al, PLB 680 365 (2009)

#### Angular dependence of energy fluxes



6-dimensional black hole

Figures taken from Casals et al, PLB 680 365 (2009)

### Simulating the "spin-down" phase

Spin-down phase incorporated into two BH simulators:

- BlackMax [ Dai et al, PRD **77** 076007 (2008)];
- CHARYBDIS2 [Frost et al, JHEP 10 (2009) 014].

Emission of standard model particles on the brane

Ignore gravitation emission/emission into the bulk

### Effect of rotation



Figures taken from Frost et al, JHEP 10 (2009) 014

#### Black hole evolution



Figures taken from Frost et al, JHEP **10** (2009) 014

## Conclusions

"Spin-down" phase of evaporation of brane black holes

- Hawking radiation has strong angular dependence
- Rotating black holes emit fewer particles, with higher energy
- "Spin-down" phase significant for most of the life of the black hole