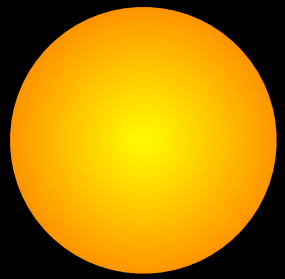
The Cosmic battery and the Inner Edge of the Accretion Disk

Ioannis Contopoulos, RCAAM, Academy of Athens
Demetrios Papadopoulos, Univ. of Thessaloniki

Outline

- Measuring black hole spin
- Black hole accretion and outflows
- The Cosmic Battery
- Accumulated magnetic flux

Measuring stellar diameters



We take a spectrum

↓

Temperature

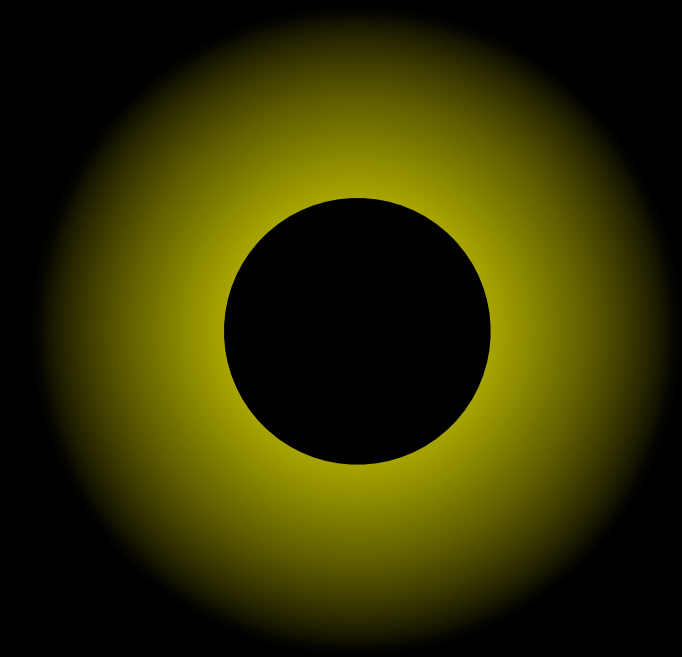
We measure the apparent luminosity

↓

Actual luminosity

→ Surface area (diameter)

Measuring black hole spin



We take a spectrum

↓

Accretion disk model

We measure the apparent luminosity

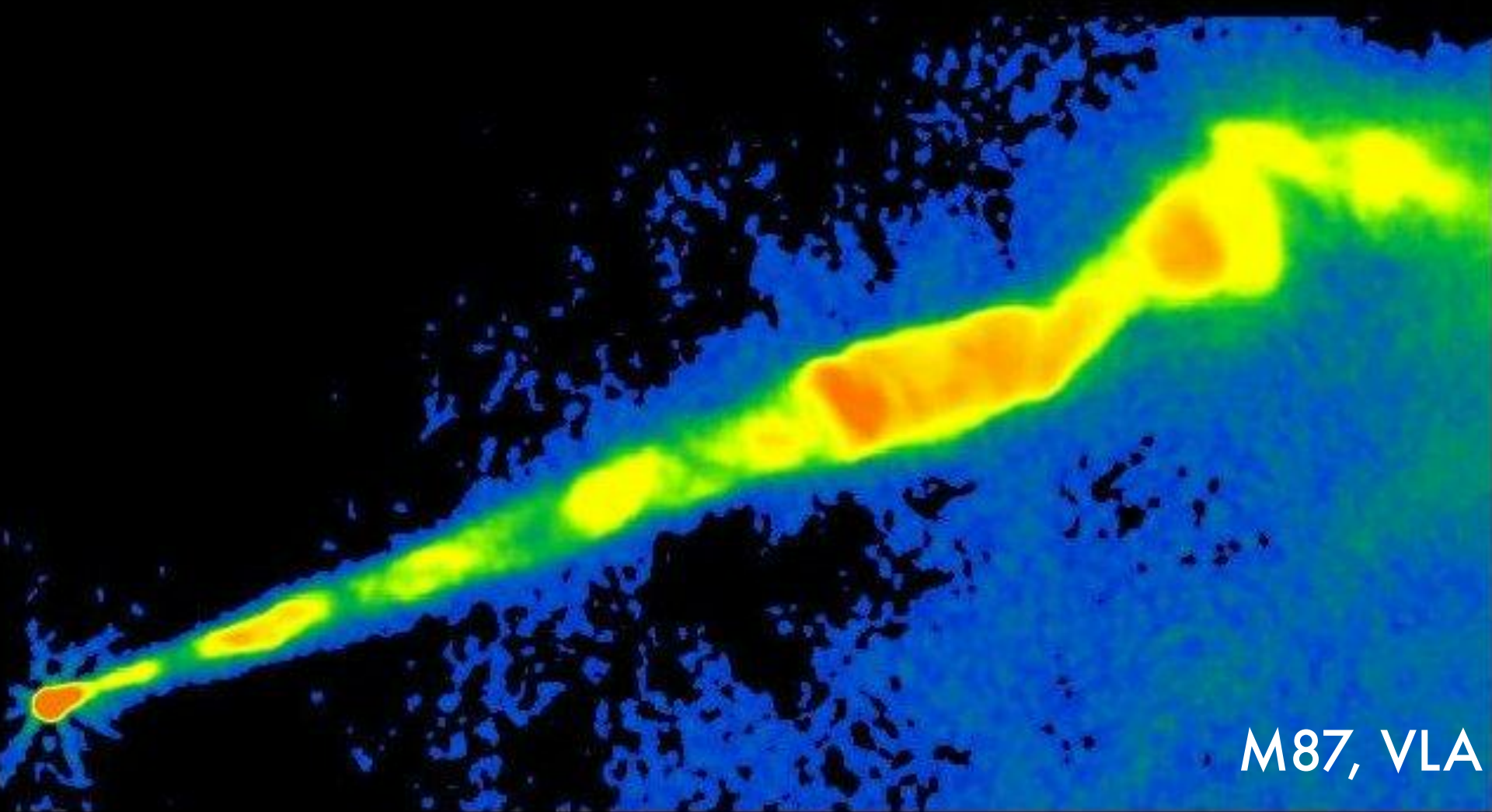
↓

Actual luminosity

→ Hole diameter

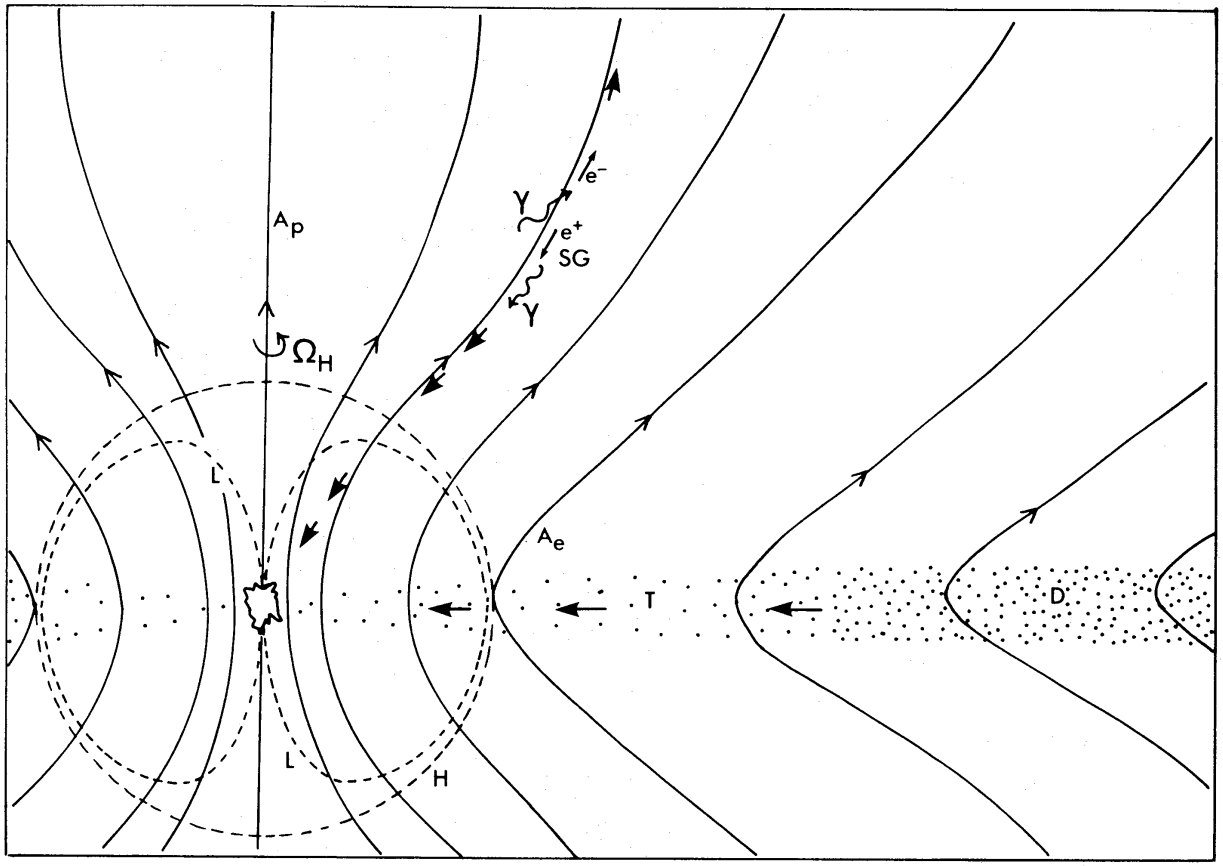
→ ISCO (black hole spin)

Black hole accretion and outflows



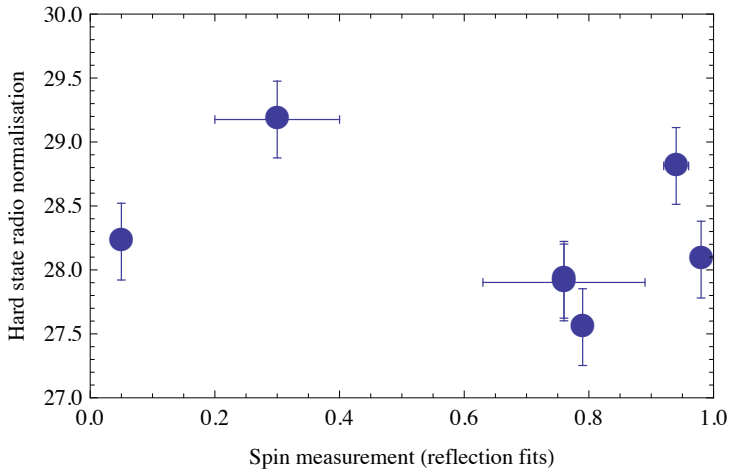
Black hole accretion and outflows

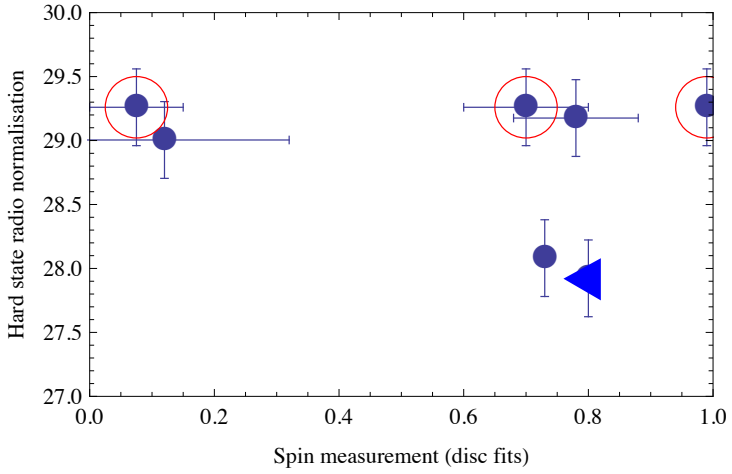
$$\mathcal{E}_{EM} \propto \Omega_H^2 \Psi_m^2$$

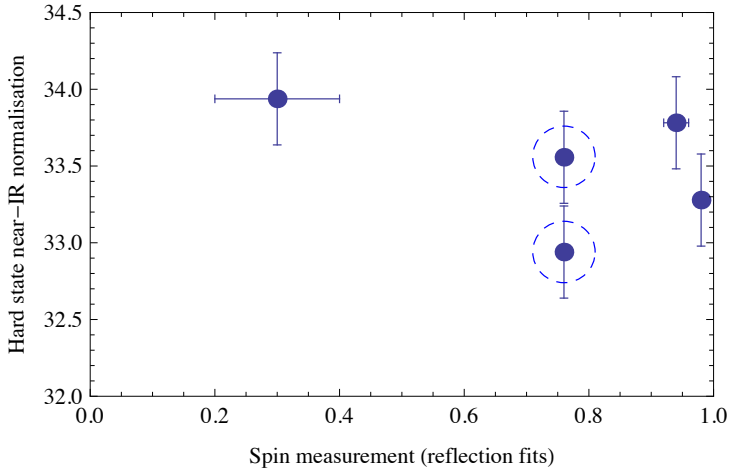


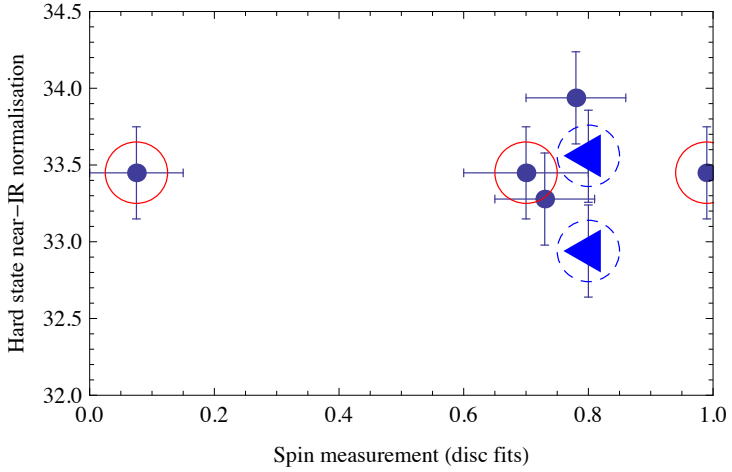
Blandford, Znajek 1977

Black hole accretion and outflows



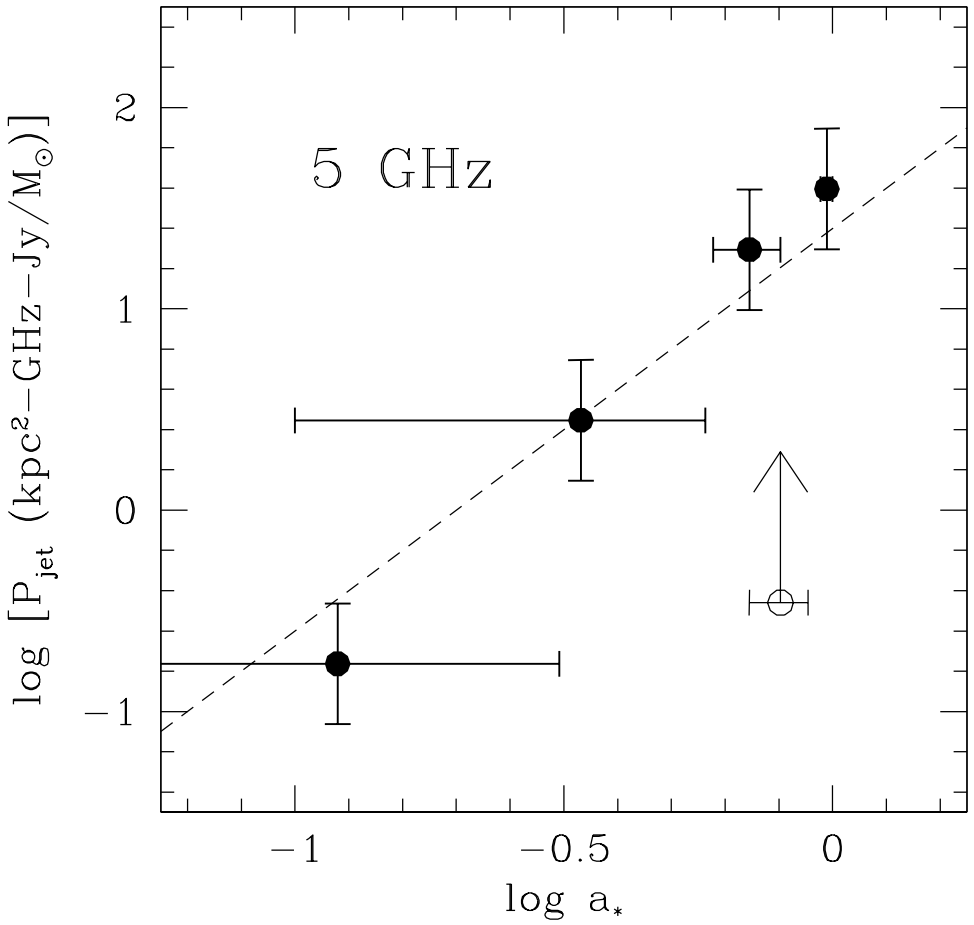






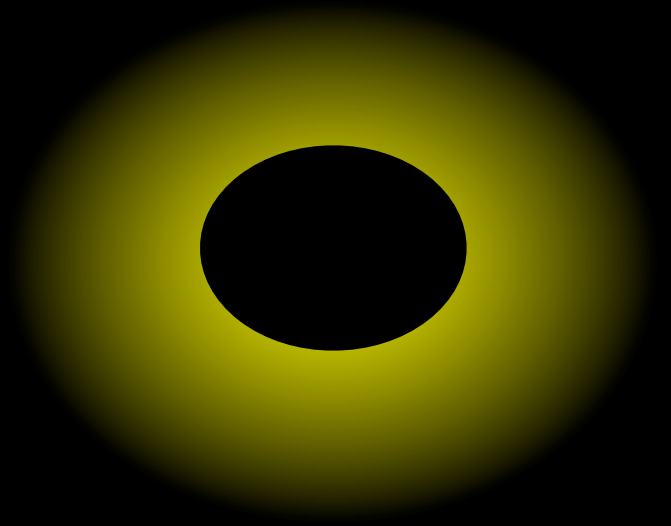
Fender, Gallo, Russell 2010

Black hole accretion and outflows



Narayan, McClintock 2012

Black hole accretion and outflows



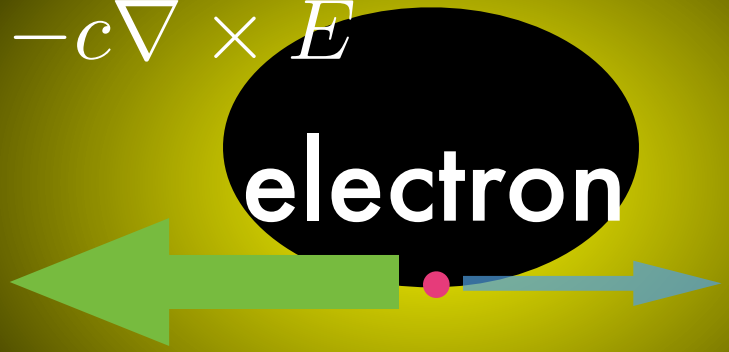
Accumulated magnetic flux

Inner edge of the disk

The Cosmic Battery

$$\nabla \times B = \frac{4\pi}{c} J \qquad -eE + F_{PR} = m_e \frac{\mathrm{d}v_e}{\mathrm{d}t}$$

$$\frac{\partial B}{\partial t} = -c \nabla \times E \qquad eE = m_p \frac{\mathrm{d}v_p}{\mathrm{d}t}$$

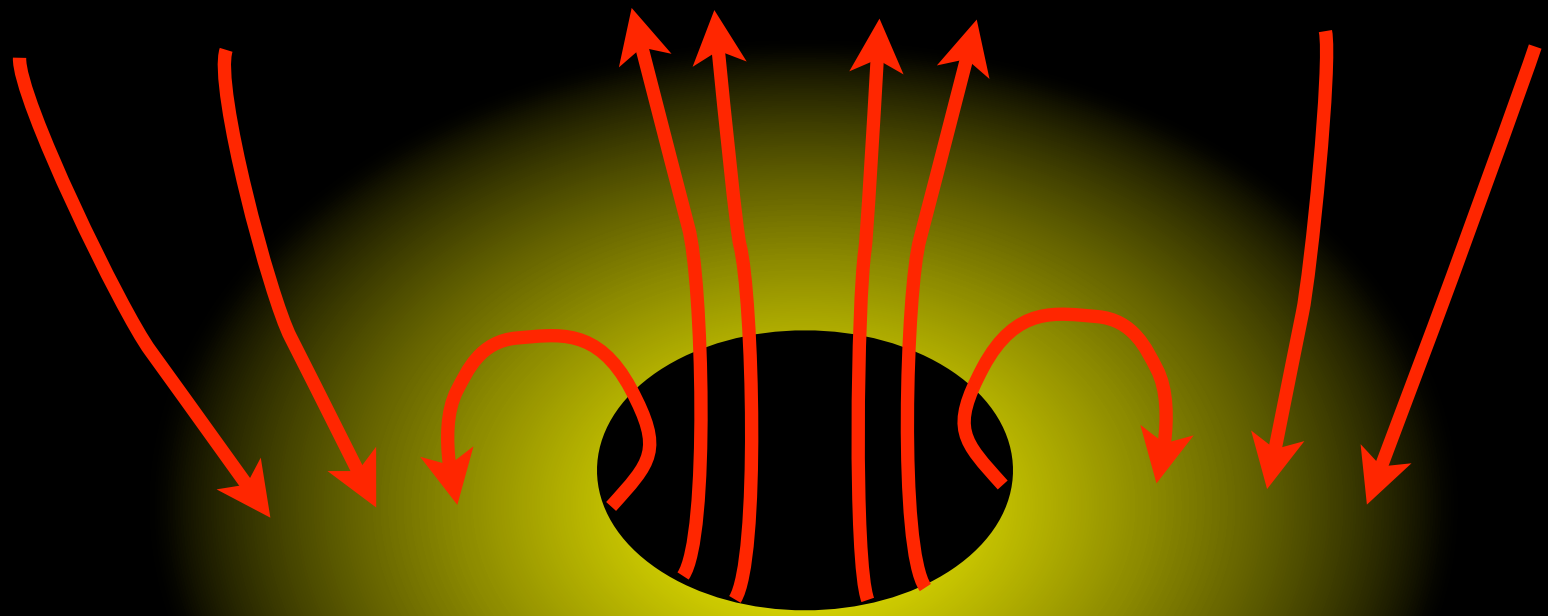


$$F_{PR} = -\frac{L \sigma_T}{4\pi r^2 c} \frac{v_\phi}{c}$$

The Cosmic Battery

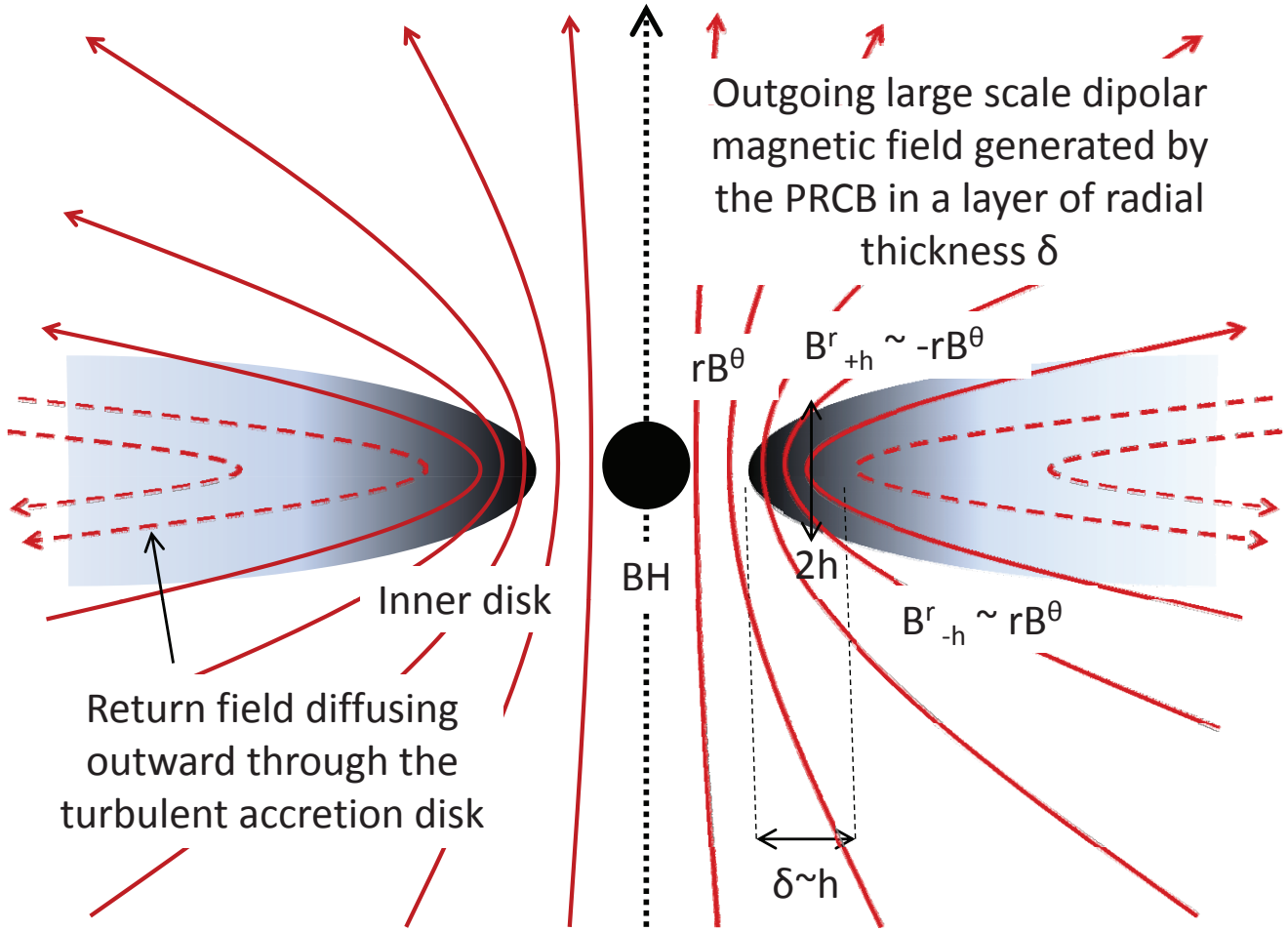
$$\frac{\partial B}{\partial t} = -c\nabla \times (\ldots + F_{PR}/e)$$

The Cosmic Battery



$$\frac{\partial B}{\partial t} = -c\nabla \times (\ldots + F_{PR}/e)$$

Accumulated Magnetic Field



Contopoulos, Papadopoulos 2012

Accumulated Magnetic Field

$$\mathcal{F}(x,\tilde{l};\lambda,\mathrm{v}_A^2 x_{\rm ISCO})=0\ , \quad \text{and}$$

$$\frac{\partial}{\partial x}\mathcal{F}(x,\tilde{l};\lambda,\mathrm{v}_A^2 x_{\rm ISCO})=0\ ,$$

where,

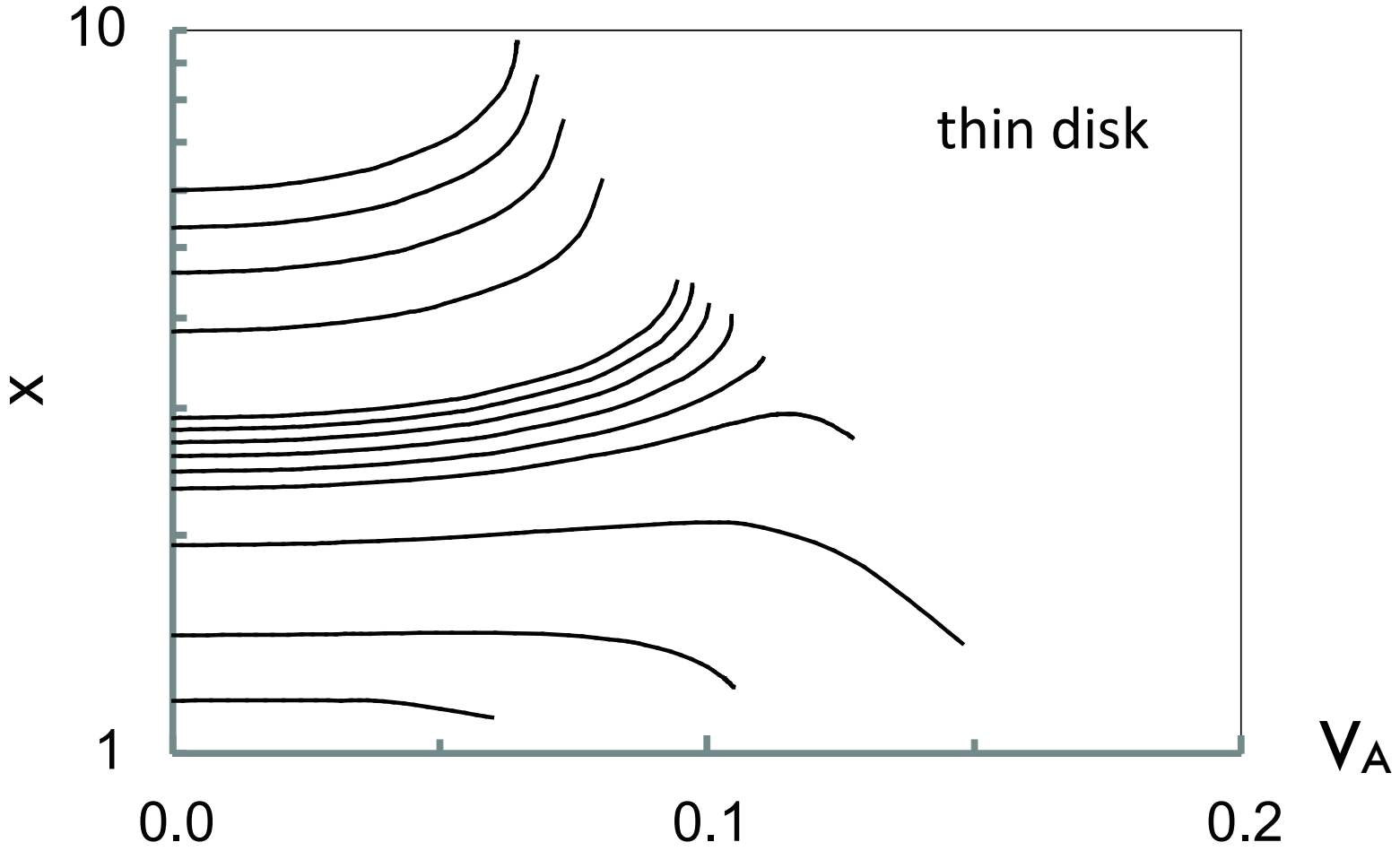
$$\mathcal{F}(x,\tilde{l};\lambda,\mathrm{v}_A^2 x_{\rm ISCO}) \equiv \left(1-\frac{2}{x}\right)^2\frac{\tilde{l}^2}{x^3}-\frac{1}{x^2}$$

$$+\frac{\mathrm{v}_A^2 x_{\rm ISCO}}{x^2}\left\{(2\lambda-1)\left(1-\frac{1}{x}\right)\right.$$

$$\left.-\frac{\tilde{l}^2}{x^2}(1-\frac{2}{x})\left(2\lambda-\frac{3}{2}-\frac{2\lambda-3}{x}\right)\right\}\left[1-\frac{\tilde{l}^2}{x^2}(1-\frac{2}{x})\right]$$

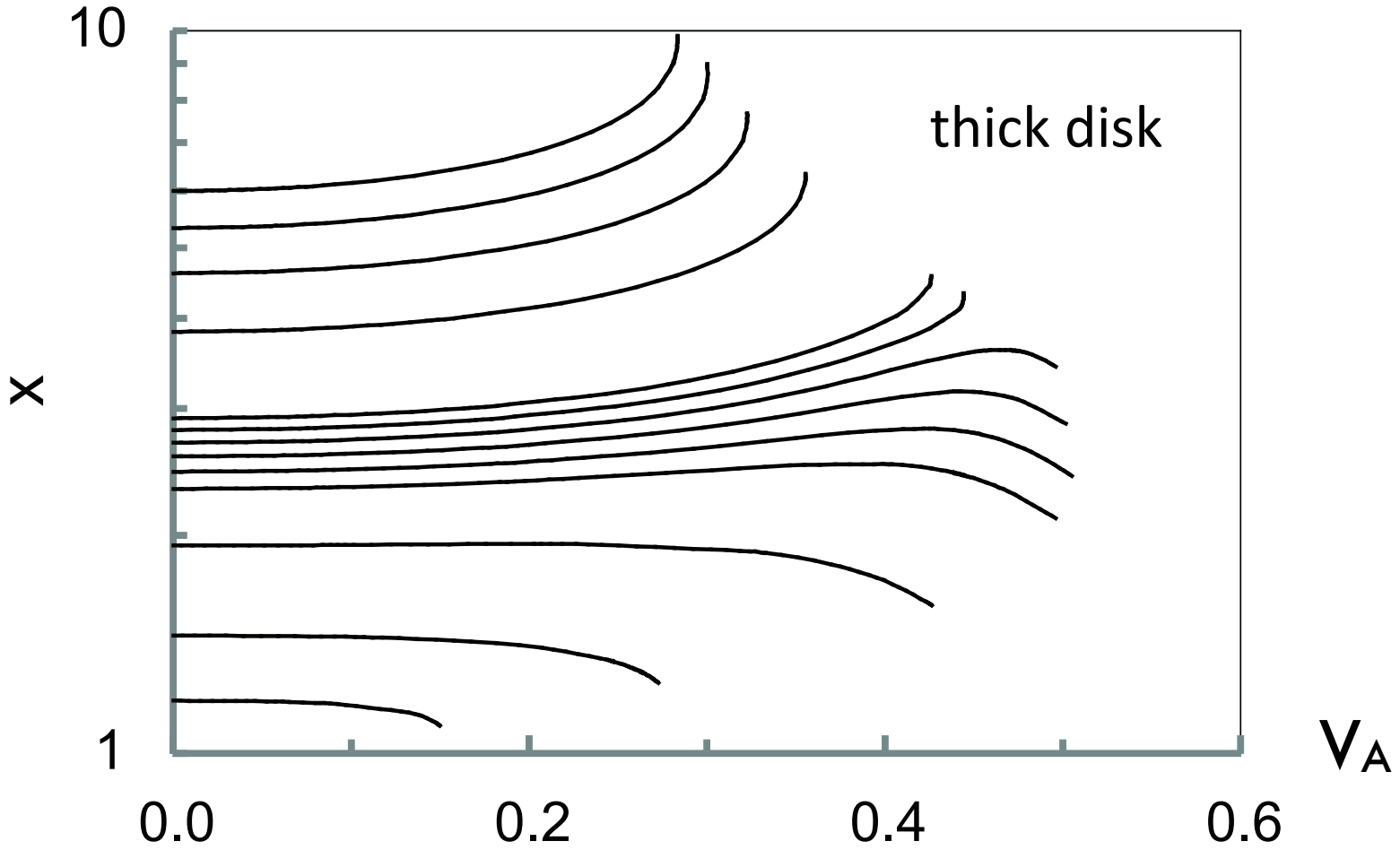
Contopoulos, Papadopoulos 2012

Accumulated Magnetic Field



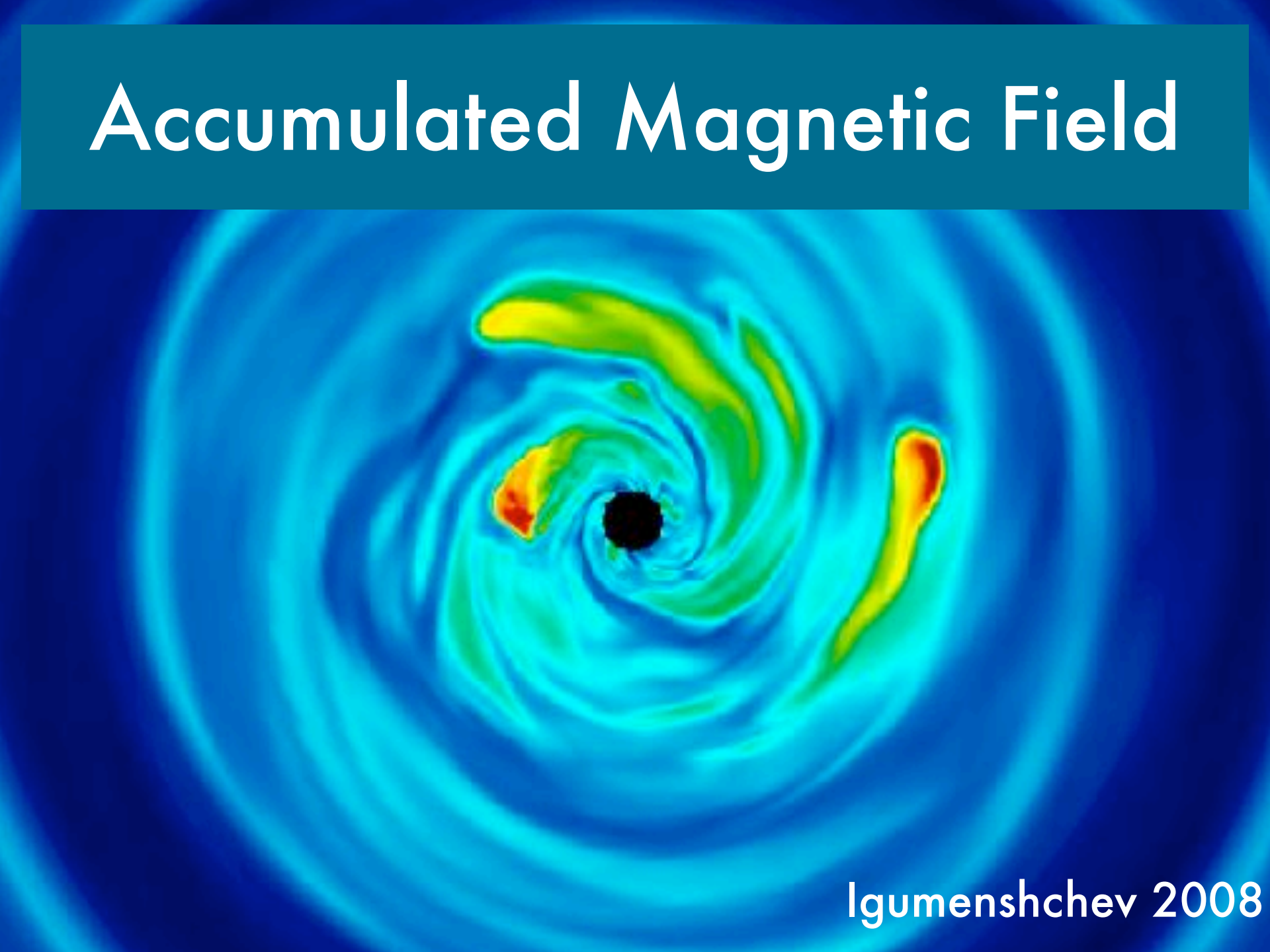
Contopoulos, Papadopoulos 2012

Accumulated Magnetic Field



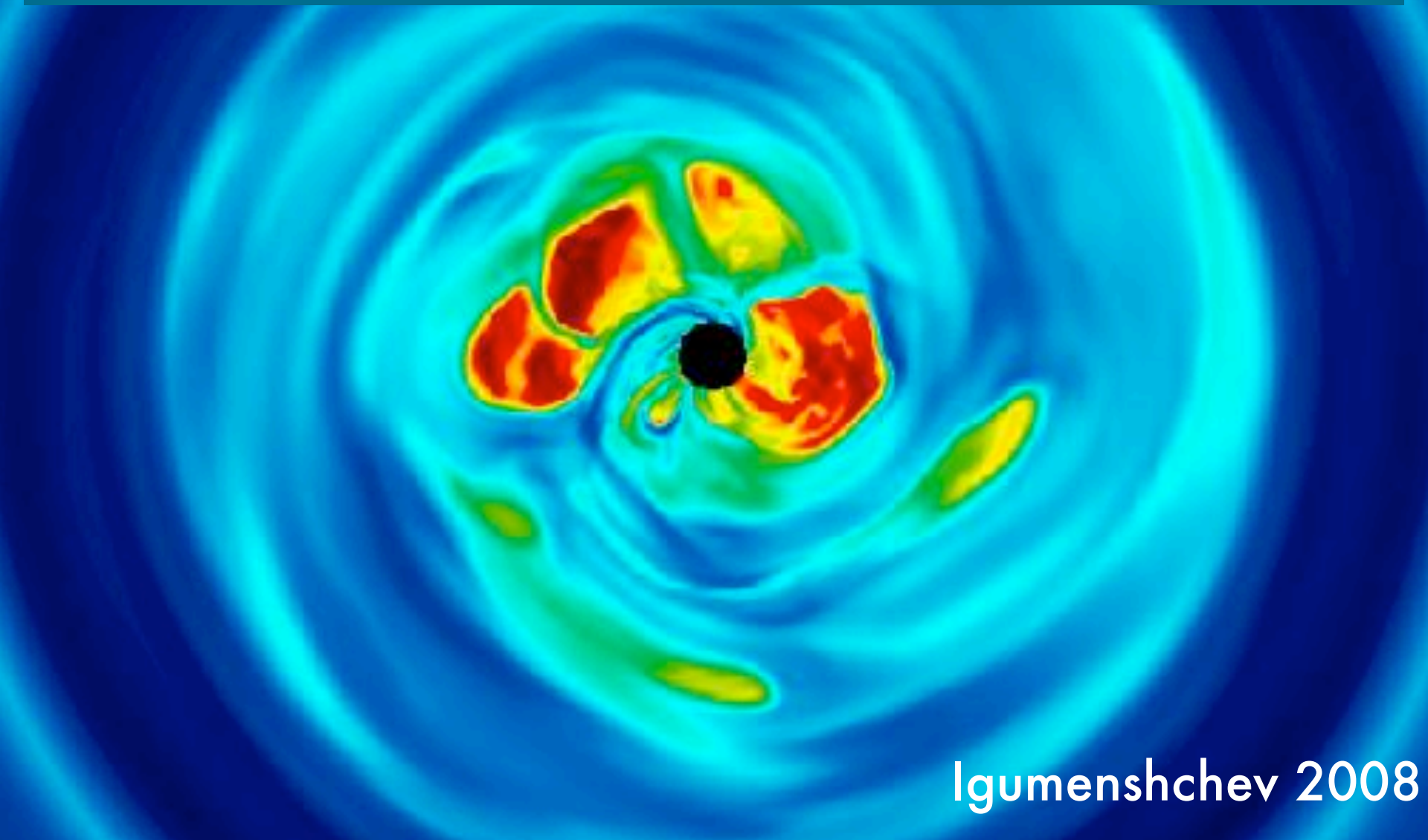
Contopoulos, Papadopoulos 2012

Accumulated Magnetic Field



Igumenshchev 2008

Accumulated Magnetic Field



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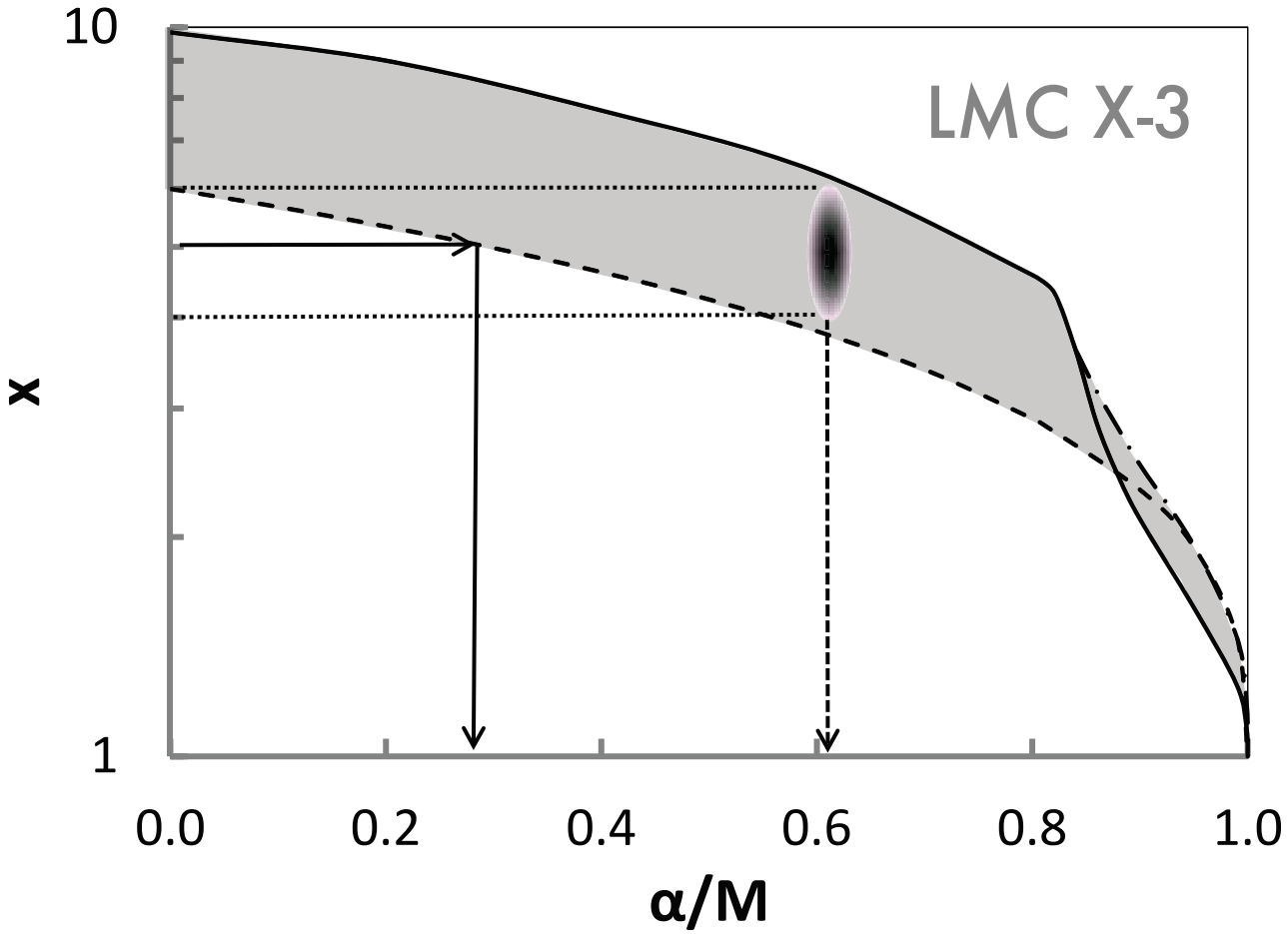
Accumulated Magnetic Field



Contopoulos, Papadopoulos 2012

Magnetic Field: the extra parameter