Radiation from Rotating Objects

- Magnetic field not aligned with rotation.
- Time varying magnetic dipole.
- Dipole radiation at frequency $\Omega$

What if the magnetic field is aligned with the rotational axis?
Axisymmetric Rotating Objects

Radiated photon must carry angular momentum.

Cannot couple to rigid axisymmetric star.

Kinematically, star can lose energy and angular momentum by emitting light degrees of freedom (e.g. photons).

Light degrees of freedom coupled to stellar medium.

At some level, there must be radiation!
Angular momentum of the photon couples to moments of the stellar excitation.
Massive Particles and Massive Stars

Particle of mass $\mu$, star of mass $M$
Gravitationally bound states at $r_0 \sim \frac{1}{GM\mu^2}$

Bose enhancement $\Rightarrow$ exponential amplification!
Extremal Objects

\[ \Gamma_{\text{em}} \propto \left( \frac{r}{r_E} \right)^{2(1+n)} \propto (GMc^2R)^{2(1+n)} \]

Most efficient \( \mu \sim \Omega \).

Largest \( M, R \) consistent with \( \Omega \).

Relativity \( \Omega R \leq 1 \).

Given \( \mu \), need extremal object at \( \mu \).
Efficient Super-radiance

\[ V_{\text{final}} \propto \left( \frac{r}{r_0} \right)^{2\alpha+1} \propto (GMc^2R)^{2\alpha+1} \]

For super-radiance, \(\mu - \mu_0 < 0\), with \(l \geq |m|\).

- Very low mass, lowest angular momentum mode is super-radiant.
- Large Bohr-radius

- High mass, only large angular momentum modes are super-radiant.
- Large Bohr-radius

Most efficient \(\mu \sim \Omega\)
Extremal Objects

\[ T_{\infty} \sim \left( \frac{r}{r_{g}} \right)^{2+\alpha} \sim (GM\mu^2 R)^{2+\alpha} \]

Most efficient \( \mu \sim \Omega \)

Largest \( M, R \) consistent with \( \Omega \)

Relativity \( \Omega R \leq 1 \)

Given \( \mu \), need extremal object at \( \mu \).