AXPs/SGRs in the outer gap model: confronting Fermi observations

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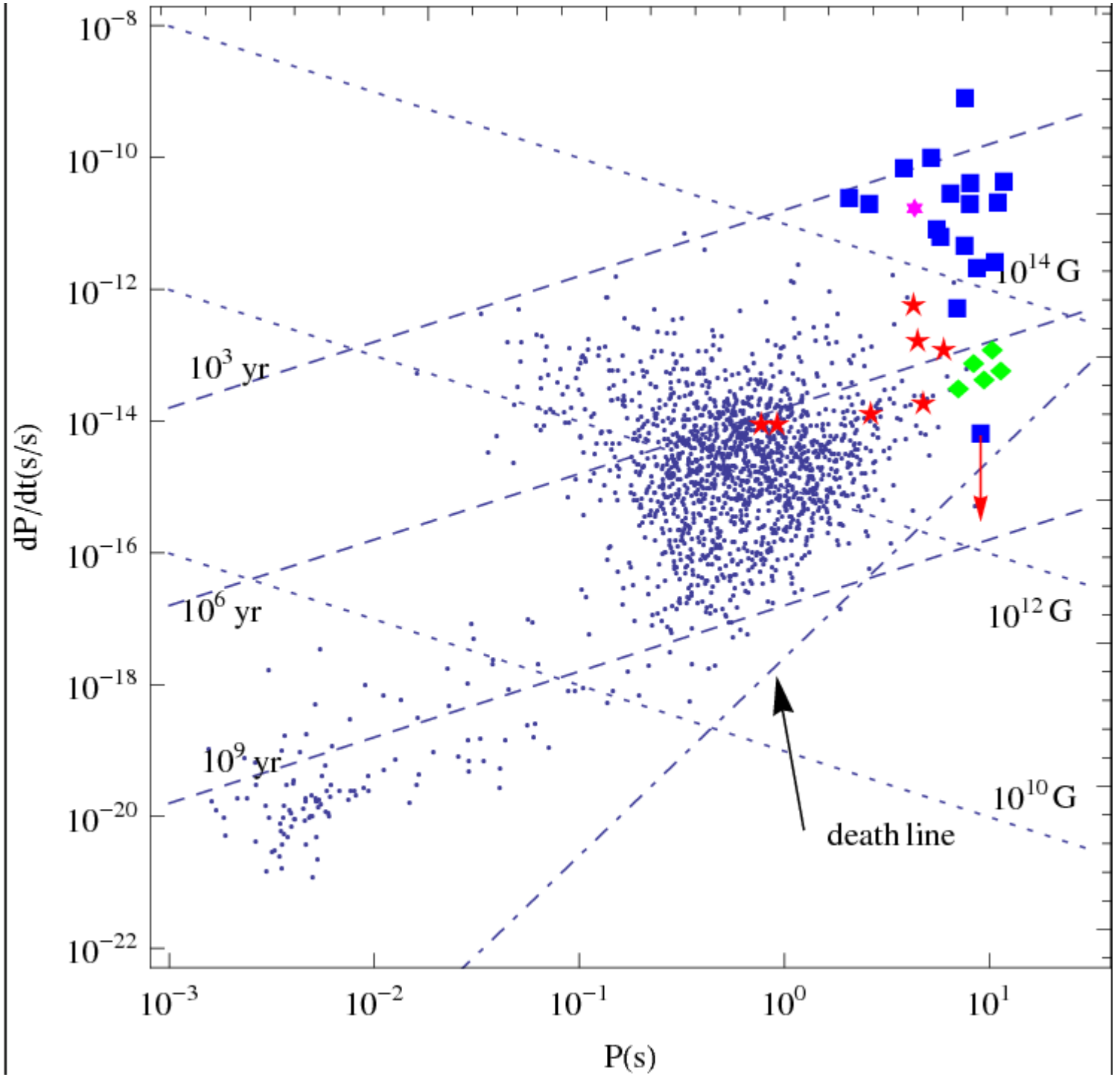
Outline

- What's AXPs/SGRs
- Fermi-LAT observations
- Application of outer gap model
- Conclusions


10^{-8}
10^{-10}
10^{-12}
10^{-14}
10^{-16}
10^{-18}
10^{-20}
10^{-22}
dP/dt(s/s)
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
P(s)
10^{14} G
10^{12} G
10^{10} G
10^{3} yr
10^{6} yr
10^{9} yr
death line

What's AXPs & SGRs

- AXPs: anomalous X-ray pulsars
  - Lx>Edot (not necessary)
  - No binary signature
- SGRs: soft gamma-ray repeaters
  - Soft: typical photon energy is lower
  - Repeater: recurrent bursts

The same population!

Magnetar model

- Magnetar =
  - young NS (SNR etc)
  - B_dip> 4.4*10^13 G (braking)
  - B_tor=10^14-10^15 G
    (burst and persistent emission and super-Eddington luminosity)

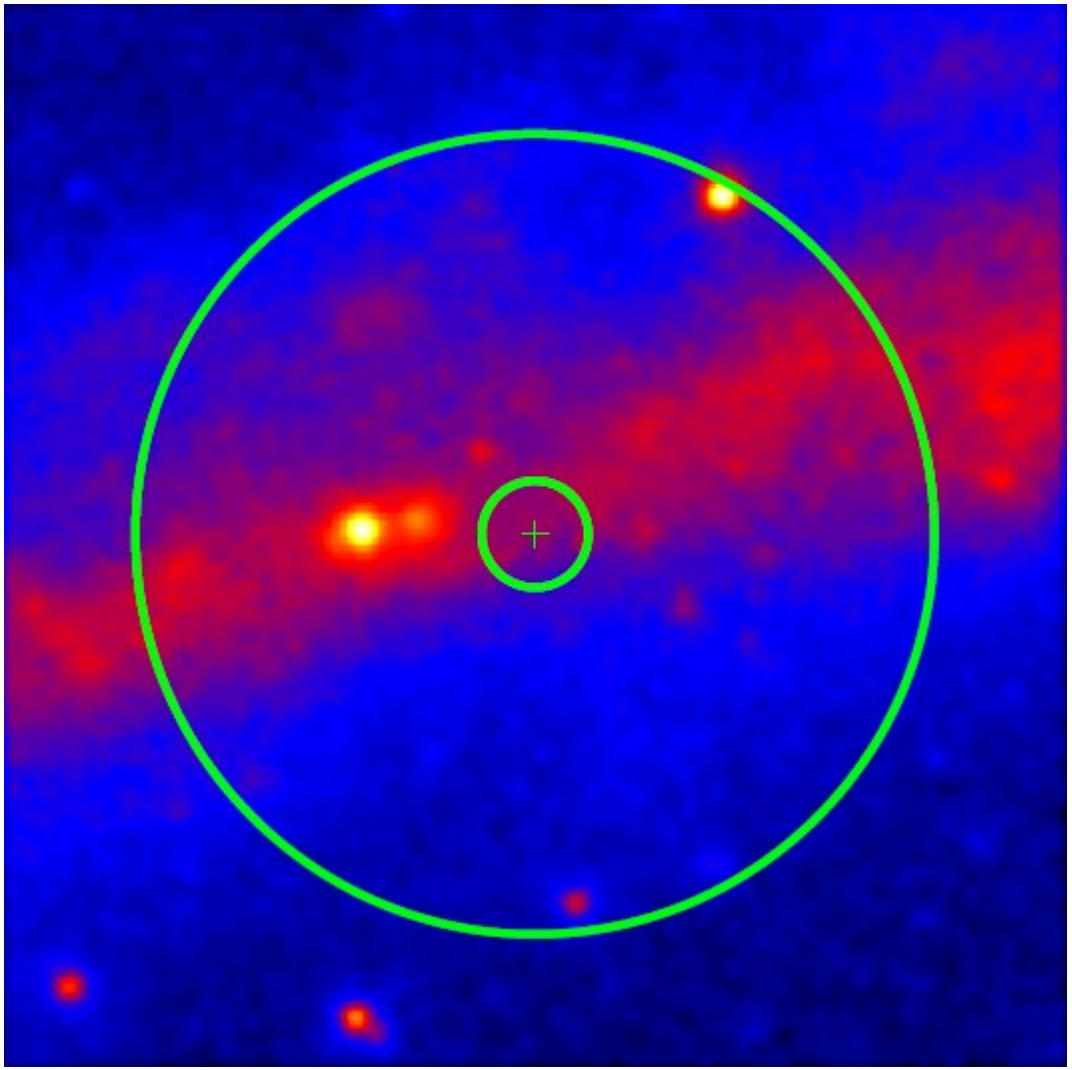
Alternatives: Fallback disk model
(Alpar 2001; Wang et al. 2006)

Fermi/LAT obs of 4U 0141+61

(Sasmaz Mus & Gogus 2010;
Tong, Song, & Xu 2010)

Exposure: 31.7 Ms

No detection!



Fermi/LAT observation of all magnetars

(Fermi-LAT collaboration 2010;
Tong, Song, & Xu arXiv:1101.2289)

TABLE 1
Fermi-LAT UPPER LIMITS ON MAGNETARS OBTAINED FROM LIKELIHOOD ANALYSIS.

Source	d* kpc	log(B) Gauss	log(L_X)* erg s^{-1}	log(L_{rot}) erg s^{-1}	TS	0.1–10 GeV ($\Gamma = 2.5$)	0.1–1 GeV ($\Gamma = 1.5$)	1–10 GeV ($\Gamma = 3.5$)	1FGL srcs within 3°
1E 1048.1−5937	3.0	14.78	34.00	33.90	0.0	<5.3 (12.0)	<3.9 (7.7)	<1.7 (0.7)	7
SGR 1900+14	15	14.81	35.44	34.34	0.0	<0.4 (0.9)	<0.8 (2.0)	<0.6 (0.2)	5
SGR 0418+5729	2.0	<12.70	31.77	<29.47	2.3	<0.4 (0.9)	<0.2 (0.4)	<0.1 (0.04)	2
SGR 1806–20	8.7	15.15	35.21	34.40	2.8	<0.6 (1.4)	<0.5 (0.9)	<0.12 (0.05)	1
4U 0142+614	5.0	14.11	35.32	32.10	3.6	<0.9 (2.0)	<0.5 (0.9)	<0.3 (0.11)	1
1E 1841−045	8.5	14.85	35.34	32.99	7.5	<3.0 (6.0)	<6.3 (13.0)	<2.4 (0.92)	8
XTE J1810–197	4.0	14.46	33.58	33.60	13.1	<5.0 (10.0)	<12.0 (23.0)	<2.0 (0.7)	7
1E 2259+586	3.0	13.76	34.43	31.70	15.6	<1.7 (3.9)	<0.6 (1.0)	<0.63 (0.24)	2
SGR 0501+4516	5.0	14.23	34.77	33.49	16.3	<1.9 (4.3)	<0.6 (1.0)	<0.5 (0.18)	1
1RXS J1708−4009	8.0	14.67	35.27	32.75	32.1	<10.0 (20.0)	<5.0 (9.0)	<9.0 (4.0)	8
CXOU J1647–4552	5.0	14.20	34.41	31.89	33.7	<10.0 (20.0)	<10.0 (20.0)	<19.0 (7.2)	7
SGR 1627–41	11	14.34	33.39	34.63	36.0	<20.0 (50.0)	<20.0 (30.0)	<5.0 (2.0)	8
1E 1547−5408	9.0	14.32	34.16	35.00	36.2	<10.0 (20.0)	<7.9 (16.0)	<2.1 (0.8)	6

The consequences?

- Challenges to the magnetar model

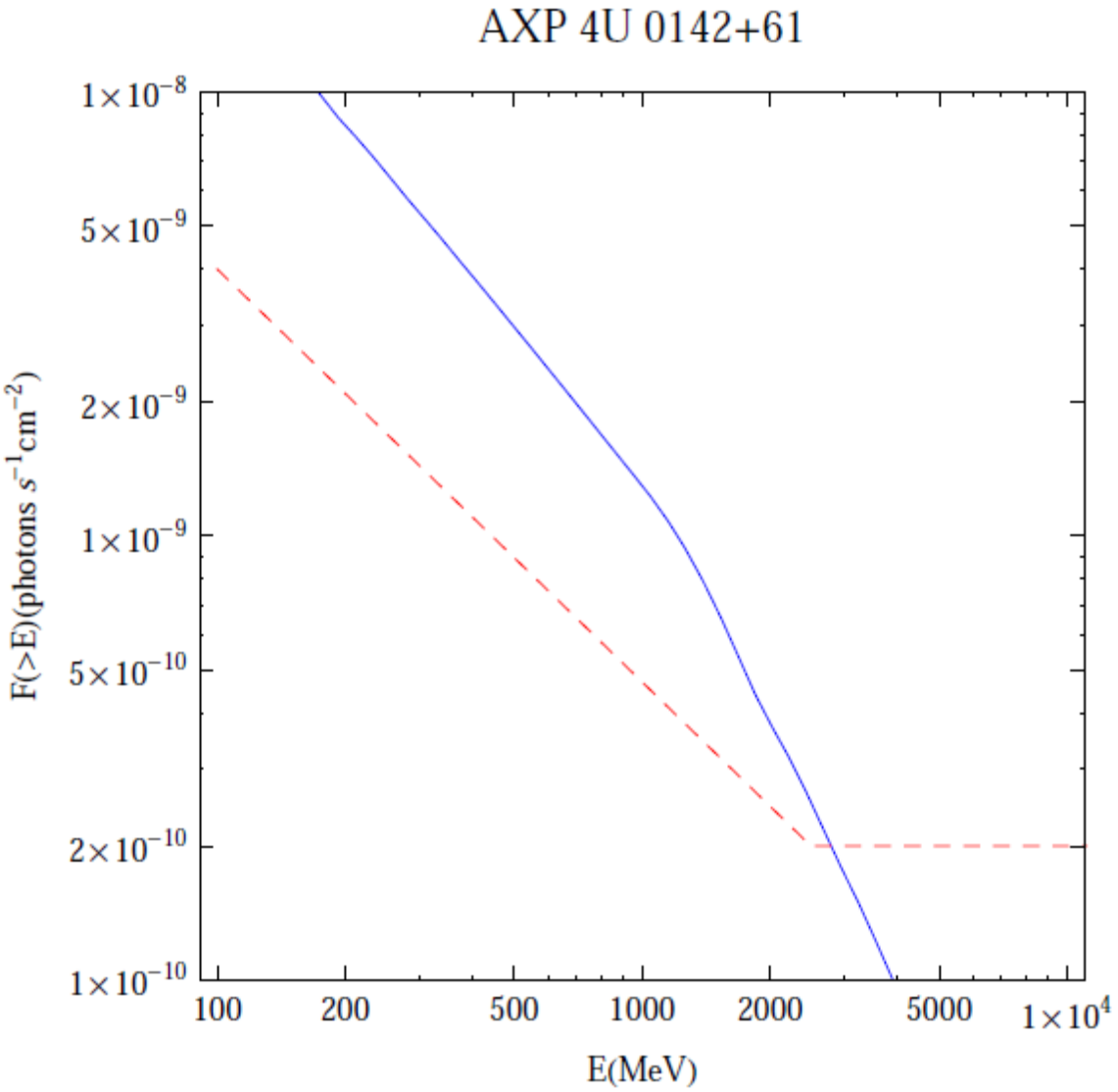
Application of outer gap model to magnetars:

- Cheng & Zhang (2001): 5 AXPs
- Tong, Song, Xu (2010): comparison with Fermi observation of 4U 0142+61
- Tong, Song, Xu (2011): comparison with Fermi observation of all magnetars

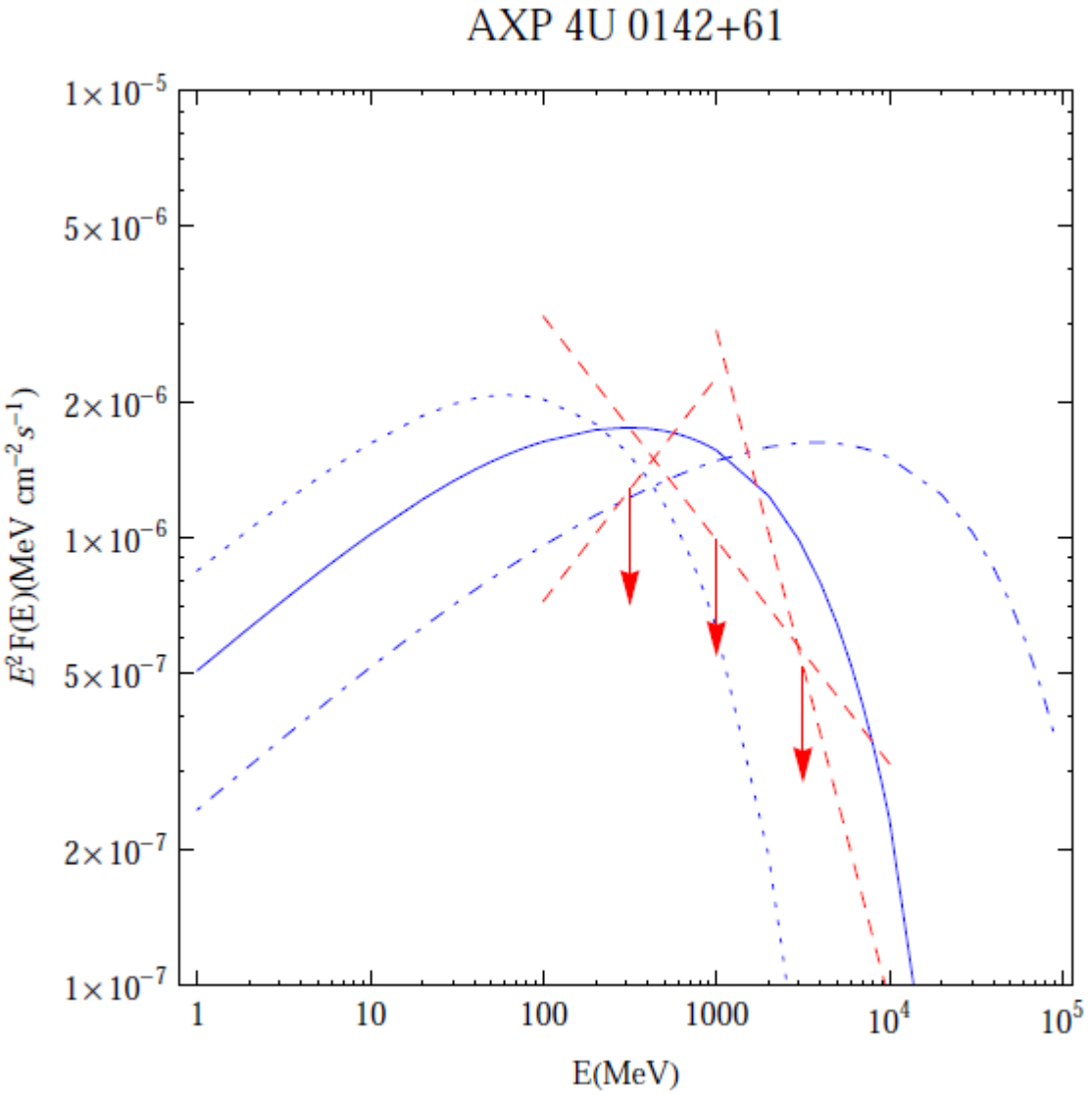
Application to magnetars: 3 SGRs+10 AXPs

- One source: gamma-ray dead
- Most sources: too far away to be seen by Fermi-LAT
- 1E 1547.0-5408, XTE J1810-197, 1E 1048.1-5937, and 4U 0142+61 can be seen by Fermi
- Fermi upper limits of 4U 0142+61 below its SEDs

Calculations for 4U 0142+61

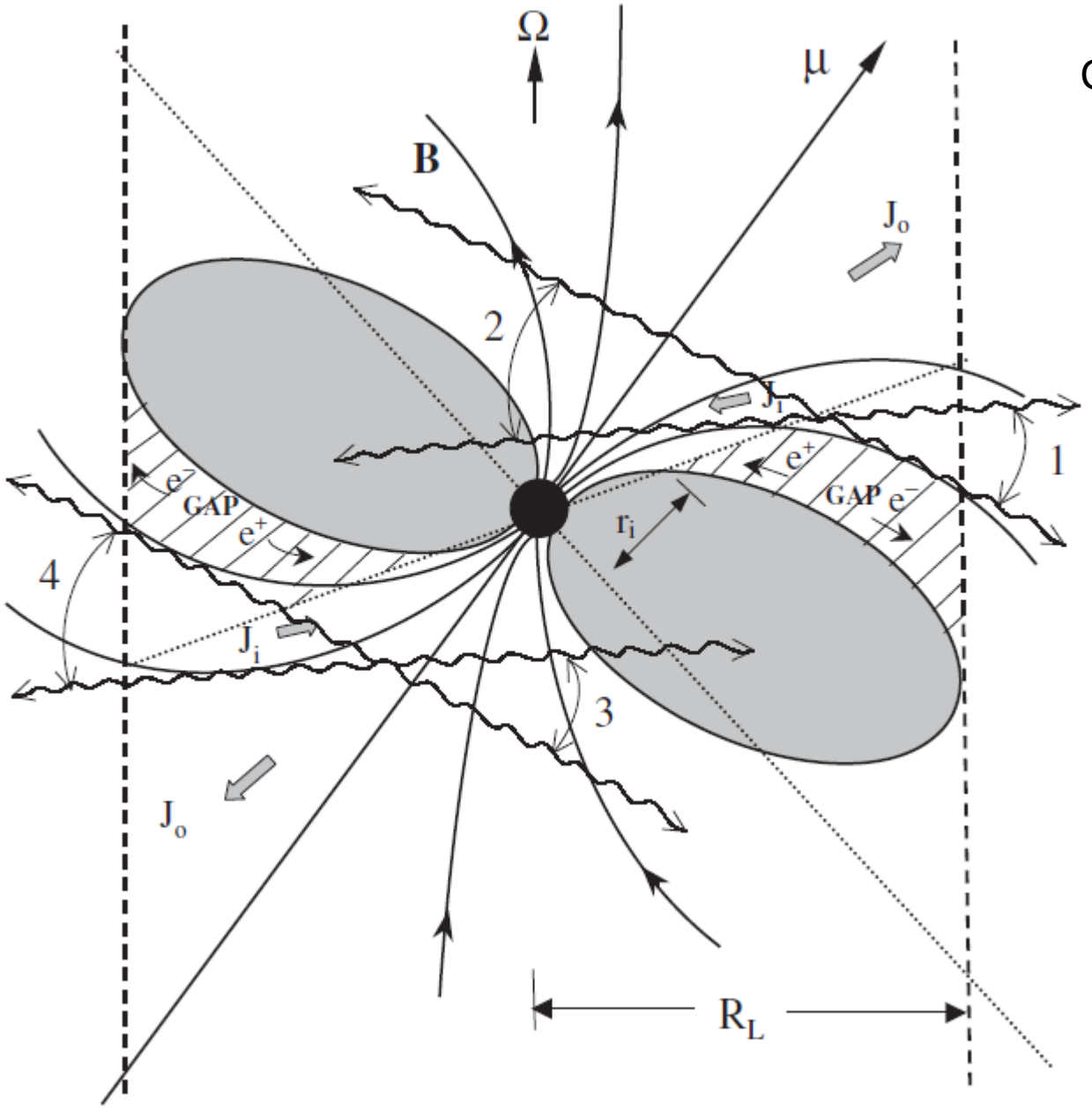


Comparison with Fermi upper limits



Summary

- Conflict between outer gap model and Fermi observations for :1E 1547.0-5408, XTE J1810-197, 1E 1048.1-5937, and 4U 0142+61
- Alternative modeling (e.g., fallback disk)
- low magnetic field SGR 0418+5729 ($B_{dip}<7.5\times10^{12}$ G)
- Deeper Fermi-LAT observation needed



Cheng 2009 ApSS

Self-consistent outer gap model

Gap thickness

- Gamma-gamma pair production

(Zhang & Cheng 1997, CGRO era)

- Gamma-B pair production

(Takata, Wang, Cheng 2010, Fermi era)