X 射线脉冲星和磁星

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1、 ***what is the "Magnetar"?***

AXP: Anomalous X-ray Pulsars

SGR: Soft Gamma-ray Repeaters

Radio Pulsars; X-ray Pulsars

2、AXP模型 & 观测检验

3、AXP 的射电观测

4、 "*Magnetar*" *or* "Quarcstar"

Basic observations: **AXP**

- spin periods **P**: 6-- 12 s
- $P_{dot} \approx$ **10^-13 to** 10^{-11} s/s
- Large timing noise
- $E_{dot} < L_X$
- spin down **time scales**: 10^3—10^5 yr
- very **soft** X--ray spectra
- **lack** of bright optical counter parts
- SNR

Mereghetti, et al. astroph/0205122

Basic observations: **SGR**

- ***super-outbursts*** → ***10^{44}reg/s***

  (low-energy gamma-ray and X-ray bursts)

- **Observations for AXP:**
  - **spin periods P: 5-- 8 s**
  - $P_{dot} \approx$ 10ˆ−13 to 10^{-11} s/s
  - **Large timing noise**
  - **$E_{dot} < L_X$**
  - **soft X--ray spectra**
  - **secular spin down on time scales: 10^3—10^5 yr**
  - **lack of bright optical counter parts**
  - **SNR**

Mereghetti, et al. astroph/0205122

Comparison: **Radio Pulsars/X-ray pulsars**

- ♠ **Radio Pulsars: 0.0014s**-8.5s
- ♠Pulsars in HMXB: 0.069s--1400s
- ♠**SGR**: 5s--8s
- ♠AXP: 6s---12s

Comparison

- ♠Periods
- ♠Energy source
- ♠ Magnetic field strength
- ♠ Pulse profile & P(t)

AXP: L_x / E_{dot}

Marsden et al. 2000、Mereghetti et al. 2002, Xue et al.2003

Source Name	P (s)	$\dot{P}$ (10^{-11}s/s)	L_x (10^{35}ergs/s)	$\dot{E}$ (10^{33}ergs/s)	η ($L_x/\dot{E}$)	B (10^{14} G)
2259+586	6.98	0.0488	1.0	0.057	1754	0.59
1841-045	11.77	4.16	2.3	1.0	230	7.1
1048.1-5937	6.45	1.5-4.0	0.34	2.2-5.9	5.8-15.4	3.1-5.1
0142+61	8.69	0.198	0.33	0.12	275	1.3
1708-4009	11.00	1.9	6.8	0.57	1193	4.6
1845-0258[a]	6.97	0.13-0.2	0.74	0.15-0.24	308-493	0.96-1.2
1838-0301[b]	5.45	–	3.0	–	–	–
0720-3125[c]	8.39	$\sim$ 0.3	$\sim$ 0.0005	$\sim$ 0.2	0.25	$\sim$ 1.6

$$\frac{dE_{\mu}}{dt} = \frac{dE_{rot}}{dt} ?$$

$$B = \left(\frac{3Ic^3}{8\pi^2 R^6}\right)^{1/2}\left(P\frac{dP}{dt}\right)^{1/2} \approx 3.2\times 10^{19} G \left(P\frac{dp}{dt}\right)^{1/2}$$

ESSENTIAL SGR PROPERTIES

	Giant Flare?	P s	$\dot{P}$ s/s	1-10 keV luminosity erg/s	B, Gauss $\left(\frac{3c^3 I P \dot{P}}{8\pi^2 R^6}\right)^{1/2}$
SGR1806-20	Dec 27 2004	7.46	$\sim 10^{-10}$	2×10^{35}	8×10^{14}
SGR1900+14	Aug 27 1998	5.16	$\sim 10^{-10}$	3×10^{34}	$2\text{-}8\times10^{14}$
SGR0525-66	Mar 5 1979	8	$\sim 7\times10^{-11}$	10^{36}	7×10^{14}
SGR1627-41	No	2.6	1.2×10^{-11}	10^{35}	2×10^{14}
SGR0501+45	No	5.8	5×10^{-12}	10^{34}	10^{14}
1E1547-5408*	No	2.1	2.3×10^{-11}	10^{33}	2.2×10^{14}

*initially thought to be an AXP

X-ray emission of Pulsars

PSR J	τ (kyr)	Total L_x (erg/s)	Pulsed L_x (erg/s)	$\dot{E}$ (erg/s)	$L_x/\dot{E}$
0534-2200	1.3	$1\ 10^{36}$	$1\ 10^{36}$	$4\ 10^{38}$	$2.5\ 10^{-3}$
0540-6919	1.7	$1.6\ 10^{36}$		$1.6\ 10^{38}$	$1\ 10^{-2}$
1513-5908	1.5	$2\ 10^{34}$	$2\ 10^{34}$	$1.6\ 10^{37}$	$1.25\ 10^{-3}$
0835-4510	11.2	$4\ 10^{32}$	$4\ 10^{31}$	$6.3\ 10^{36}$	$6.3\ 10^{-5}$
1952+3252	107.1	$1.6\ 10^{33}$	$6.3\ 10^{32}$	$4\ 10^{36}$	$4\ 10^{-4}$
1709-4428	17.4	$1.6\ 10^{32}$		$3.2\ 10^{36}$	$5\ 10^{-5}$
2337+6151	40.7	$1.2\ 10^{33}$		$6.3\ 10^{34}$	$2\ 10^{-2}$
0659+1414	109.6	$6.3\ 10^{32}$	$1\ 10^{32}$	$4\ 10^{34}$	0.016
1803-2137	15.8	$1\ 10^{33}$		$2\ 10^{36}$	$0.5\ 10^{-3}$
2229+6114	10.0	$5\ 10^{33}$		$2\ 10^{37}$	$2.5\ 10^{-4}$
0953+0755	$1.7\ 10^{4}$	$7.9\ 10^{29}$		$5\ 10^{32}$	$1.58\ 10^{-3}$
0826+2637	$4.9\ 10^{3}$	$1\ 10^{30}$		$4\ 10^{32}$	$2.5\ 10^{-3}$

与其它天体的比较

Source	P (s)	$\dot{P}$ (s/s)	L_X (ergs/s)	$\dot{E}$ (ergs/s)	η ($L_X/\dot{E}$)	B (G)
Radio PSRs	0.00156-8.51	$\sim10^{-15}$	$\sim10^{29-33}$	$\sim10^{31-34}$	0.0001-0.1	$\sim10^{8--13}$
SGRs	5.16-8.1	$\sim10^{-11}$	$\sim10^{35}$	$\sim10^{33}$	**1-100**	$\sim(5.7\text{-}8)\times10^{14}$
AXPs	5.45-11.77	$\sim10^{-11}$	$\sim10^{34}$	$\sim10^{32}$	**10-1000**	$\sim(0.59\text{-}7.1)\times10^{14}$
CCOs	0.012-0.424	$\sim10^{-13}$	$\sim10^{33}$	$\sim10^{37}$	0.0001-0.1	$\sim(1.7\text{-}3.4)\times10^{12}$
DTNs	5.16-22.69	$\sim10^{-11}$	$\sim10^{31}$	$\sim10^{31}$	0.001-0.1	$\sim(1.9\text{-}5.3)\times10^{14}$

Lyne & Smith 1998、Marsden et al. 2000、

Mereghetti et al. 2002,Guseinov et al. 2002, Xue et al.2003

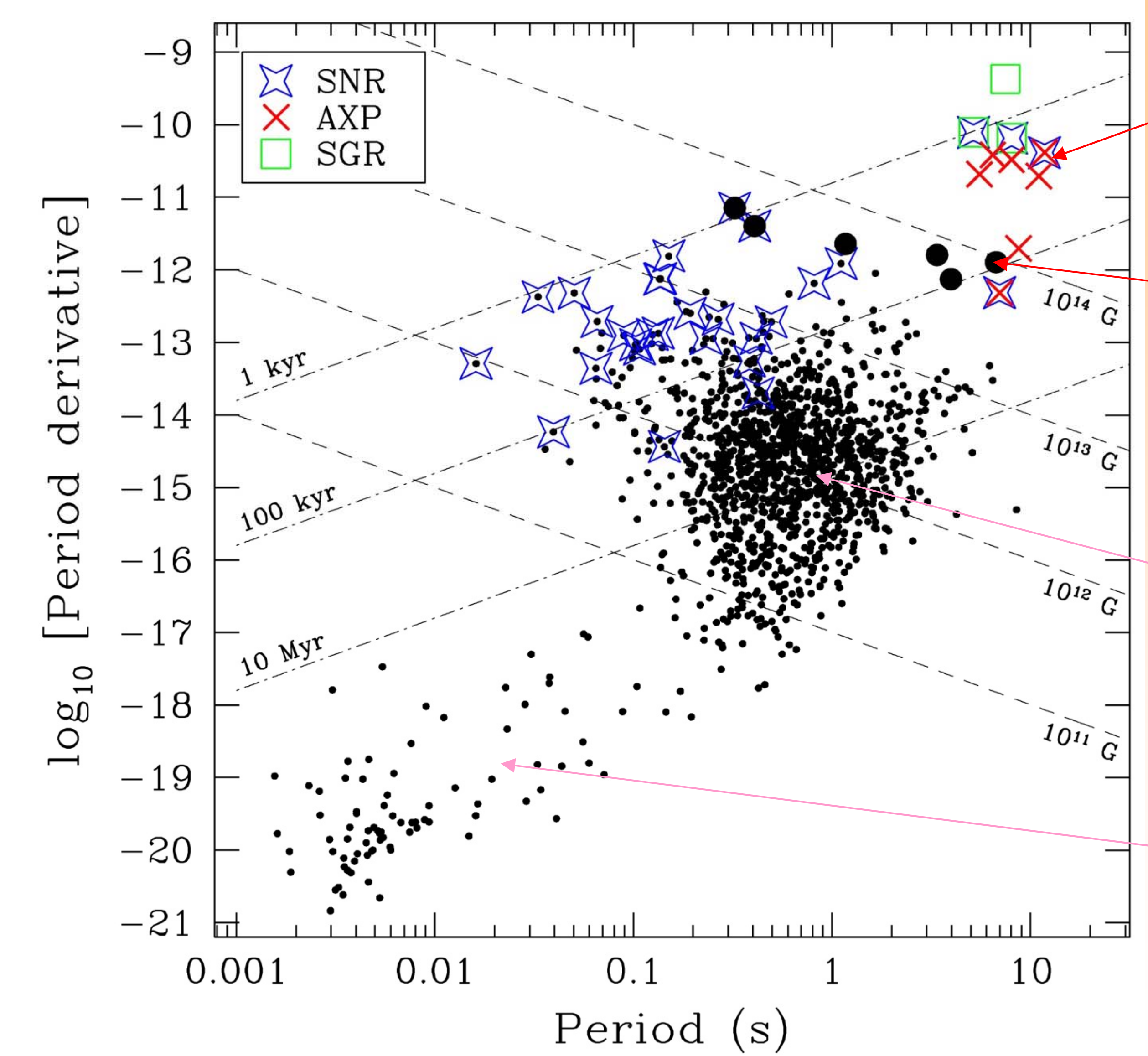
AXPs : the Anomalous X-ray Pulsars so-called (), (), the

SGRs : Soft Gamma-ray Repeaters

CCOs : the Compact Central Objects in supernova remnants (SNRs) and

DTNs : the Dim Thermal Neutron Stars

MAGNETARS COMPARED TO OTHER NS: $\dot{P}$-P DIAGRAM



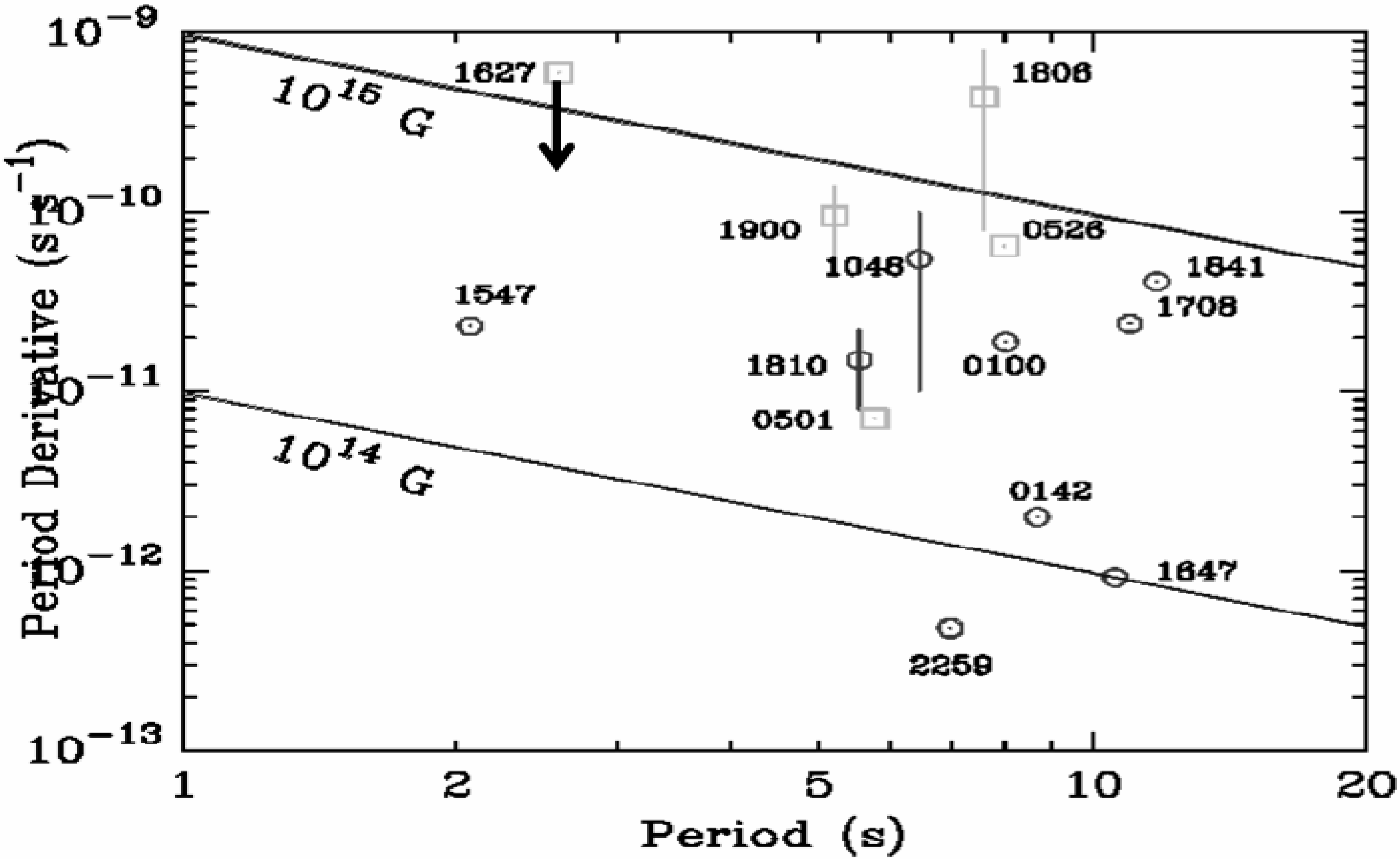
SGRs, AXPs

High B Radio Pulsars

Radio Pulsars

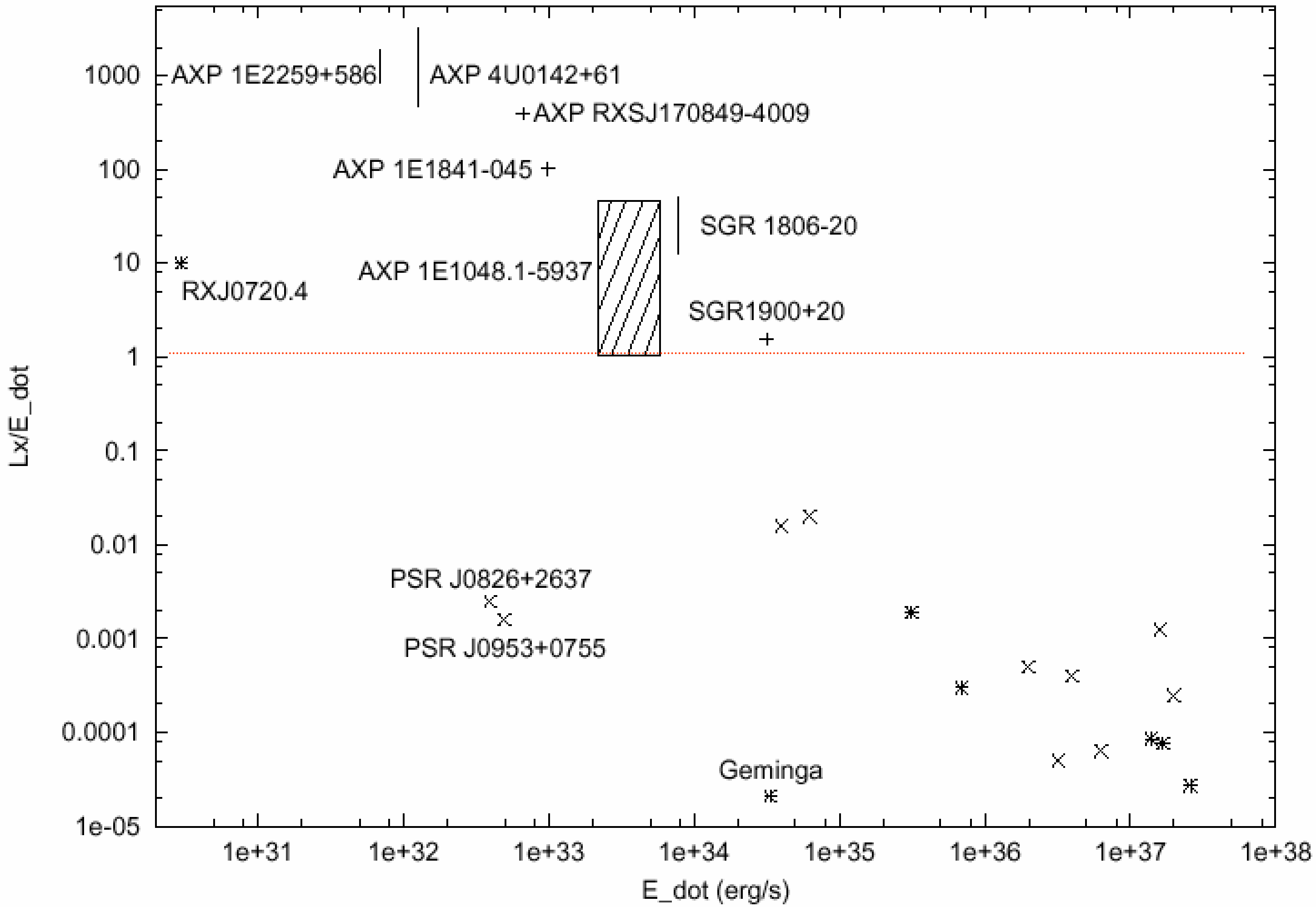
Millisecond Radio Pulsars

V. Kaspi 2006



S. Mereghetti - Neutron Stars and GRBs 2009 - Cairo

Lx---E_dot



(Guseinov et al. 2002).

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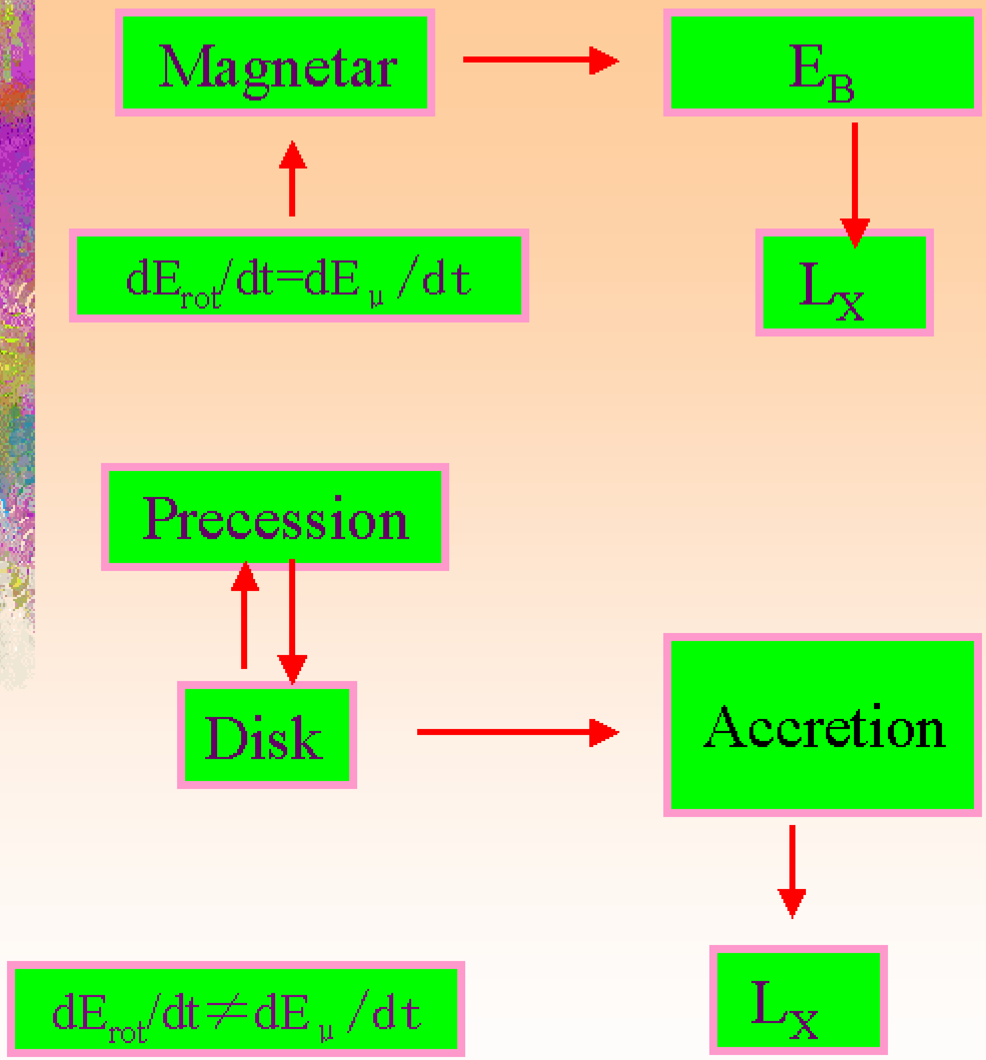
AXP: Two Models



Magnetar

Fallback Disk

AXP模型 & 观测检验

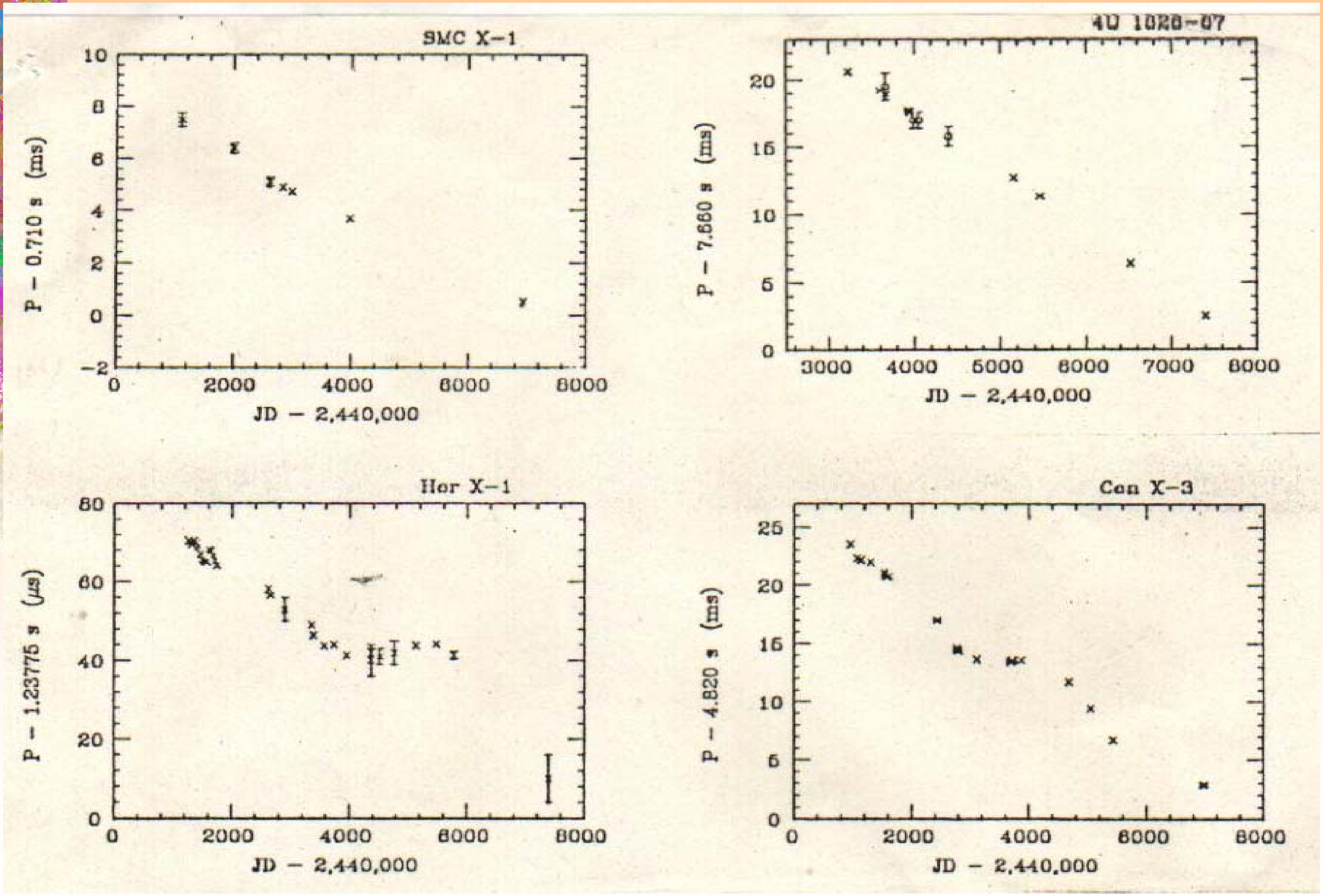
1、 *吸积模型*

2、 magnetar

3、 Quark star

4、 "*Magnetar*" *or* "Quarcstar"

HMXB X-ray pulsars: P---t diagram



Comparison: **AXP/X-ray pulsars---- Period-t**

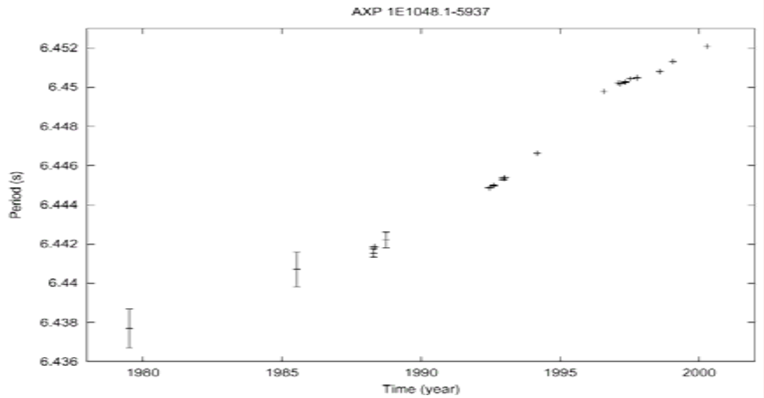


Figure 3: Period evolution of AXP 1E1048.1-5937

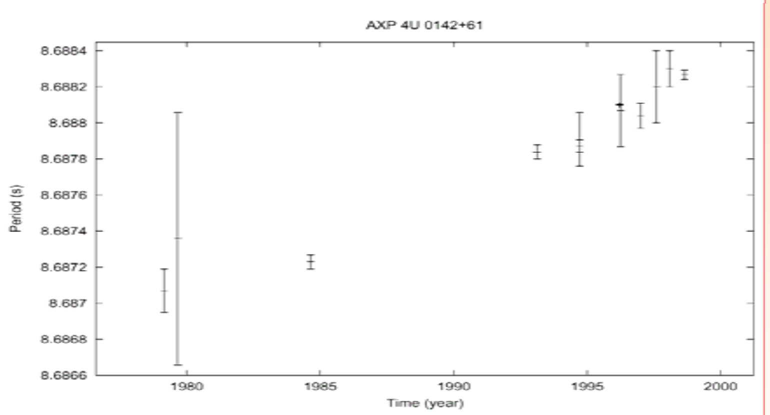
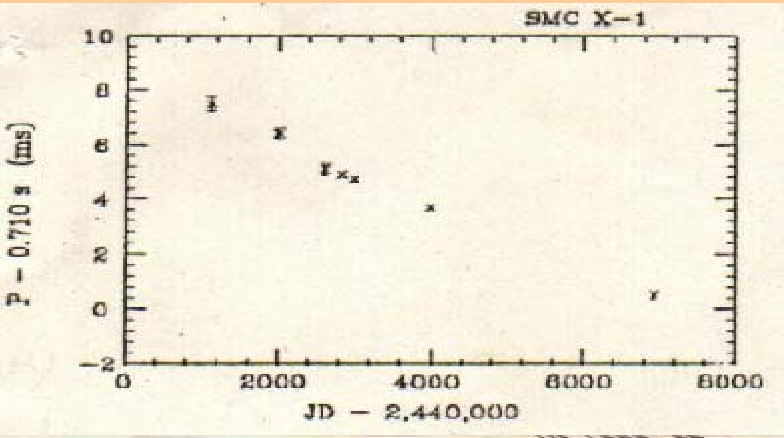
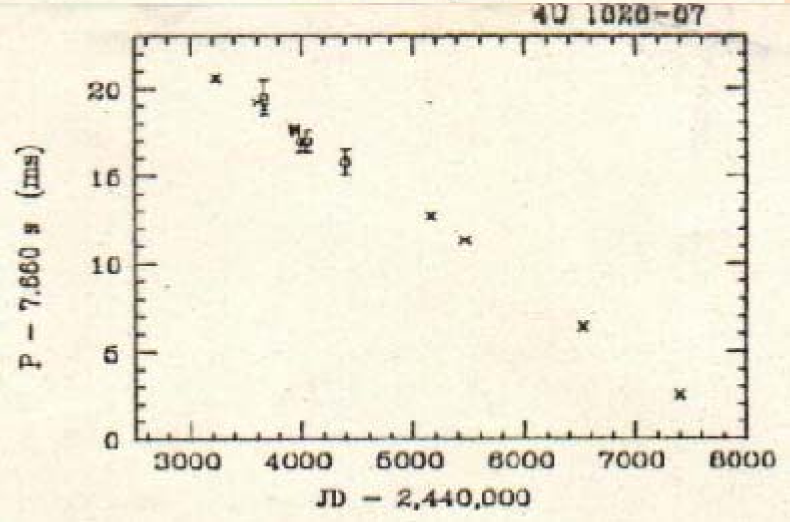


Figure 4: Period evolution of AXP 4U 0142+61

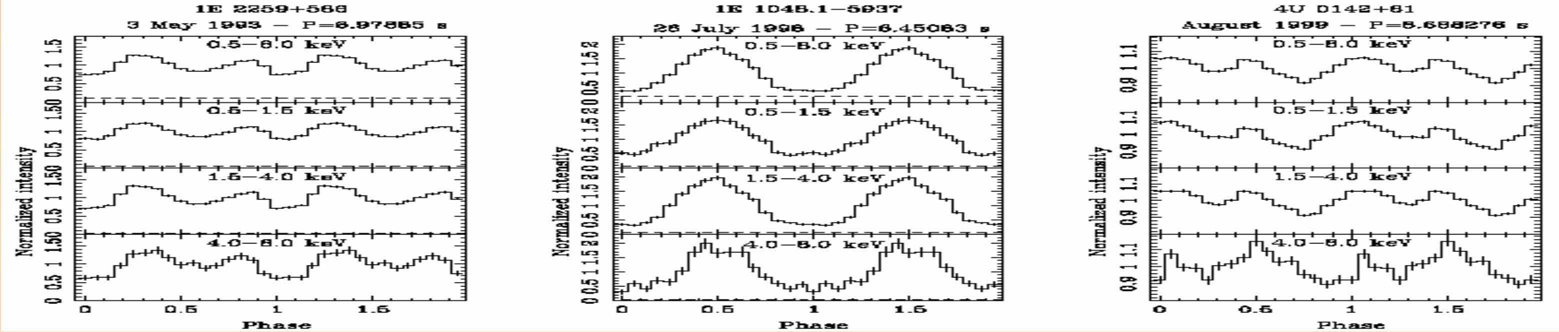


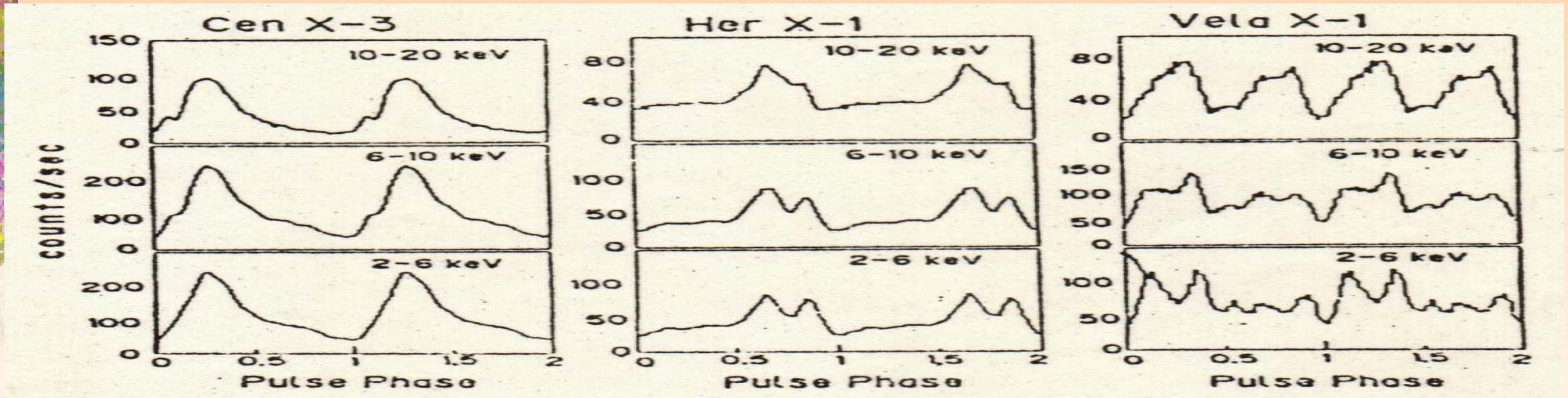


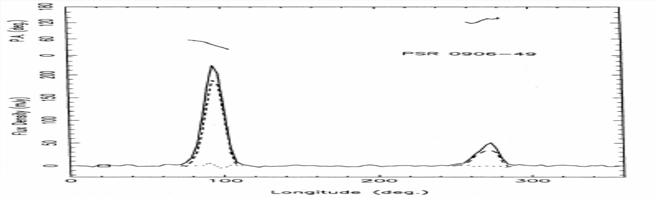
AXP(Mereghetti et al.2002)

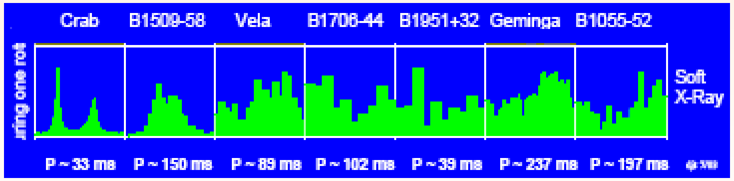
X-ray pulsar(Nagase,F., 1989)

Comparison: **Radio Pulsars/X-ray pulsars---- Pulse profiles**





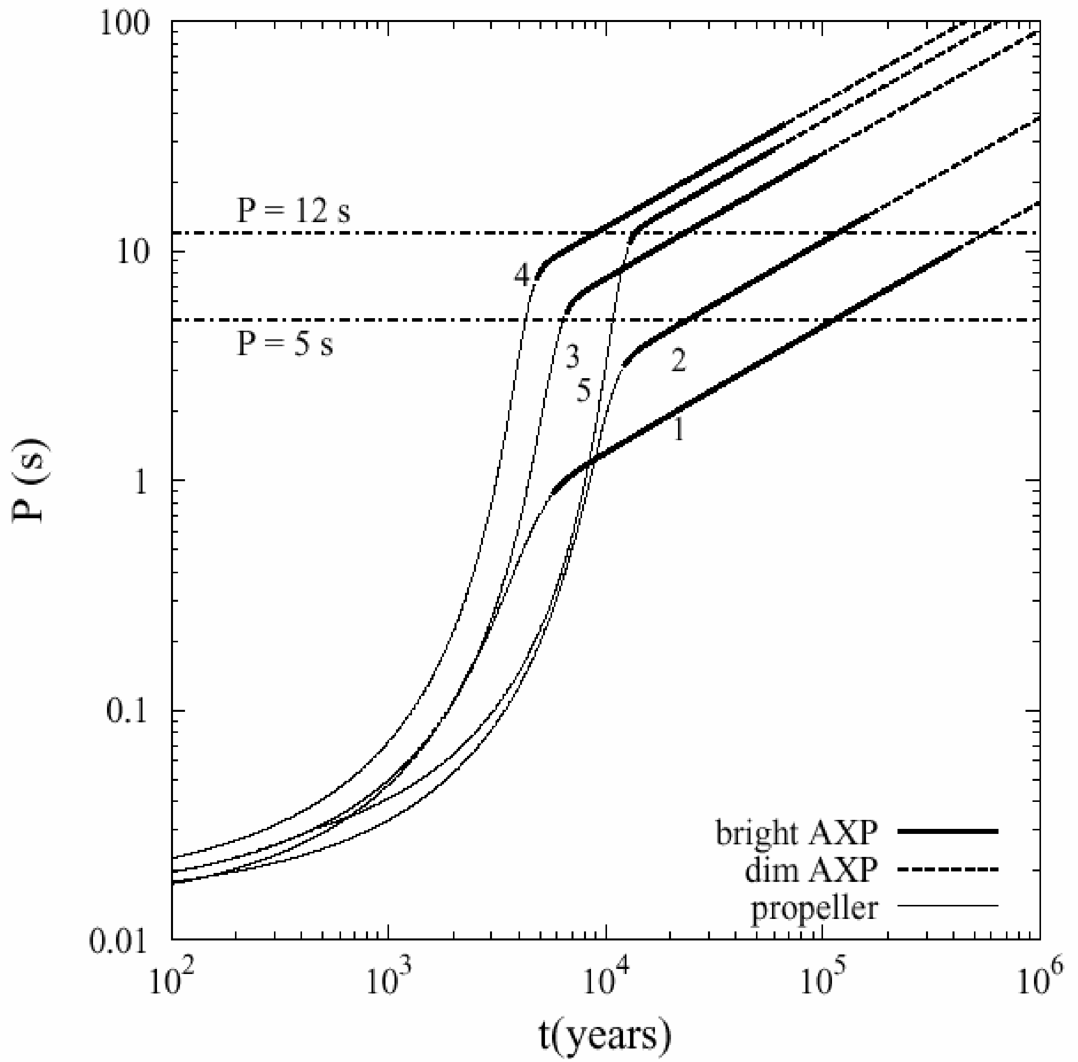




1. AXP(Mereghetti et al.02);
2. X-ray PRS(Nagase,F. 1989);
3.radio PRS(Manchester,et al.97)

7-29-2009

Period evolution of AXPs



(1) B_{12} = 1.8 ,
$M_{0,dot}$ = 5 ⑨10^28 g /s

(2) B_{12} = 2.8,
$M_{0,dot}$ = 1 ⑨10^28 g /s

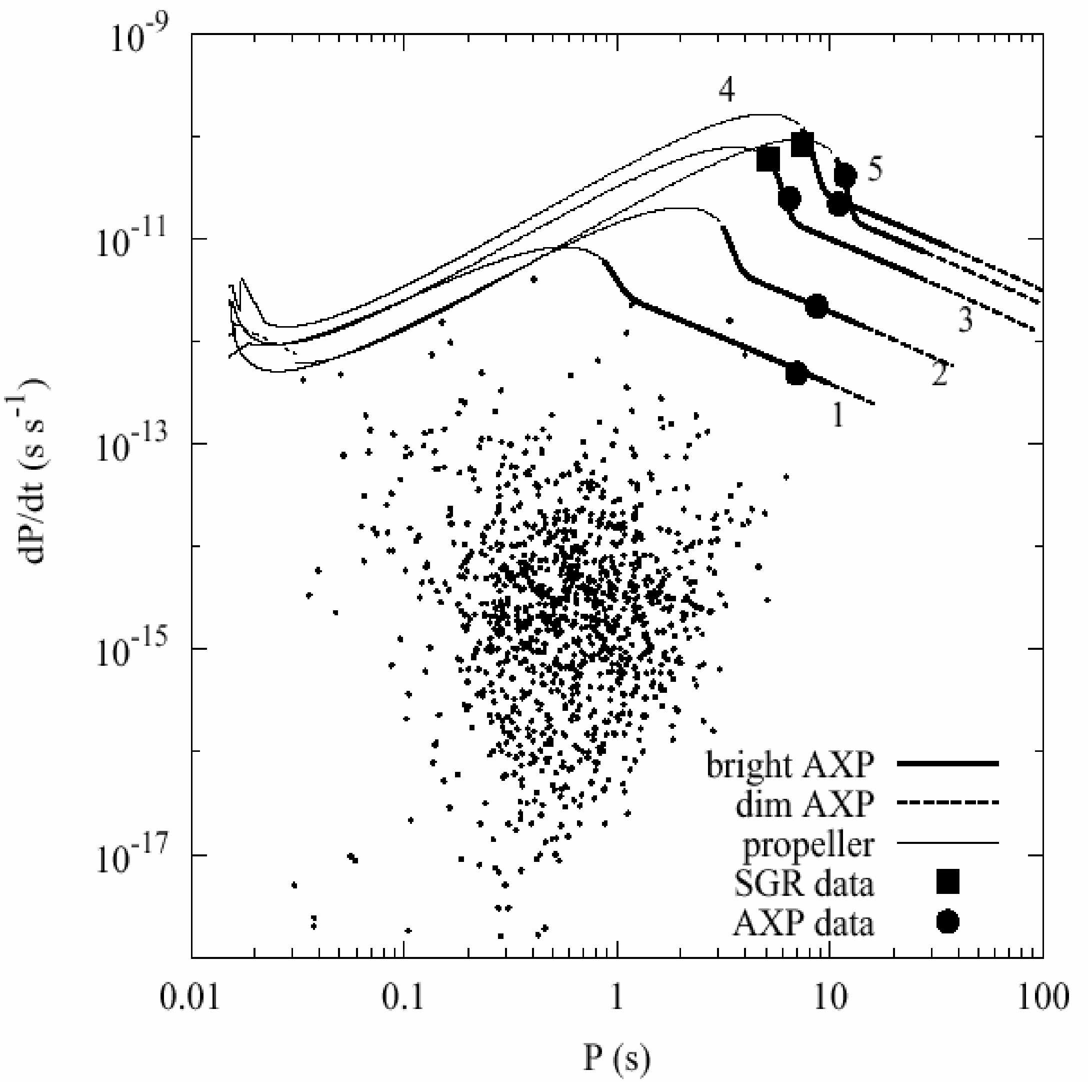
(3) B_{12} = 5.5,
$M_{0,dot}$ = 5 ⑨10^27 g /s

(4) B_{12} = 8,
$M_{0,dot}$ = 3.2 ⑨10^28 g /s

(5) B_{12} = 6,
$M_{0,dot}$ = 2 ⑨10^27 g /s

Eksi & Alpar,astroph/0309029

Evolutionary tracks in the P-P_{dot} diagram



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Eksi & Alpar,astroph/0309029

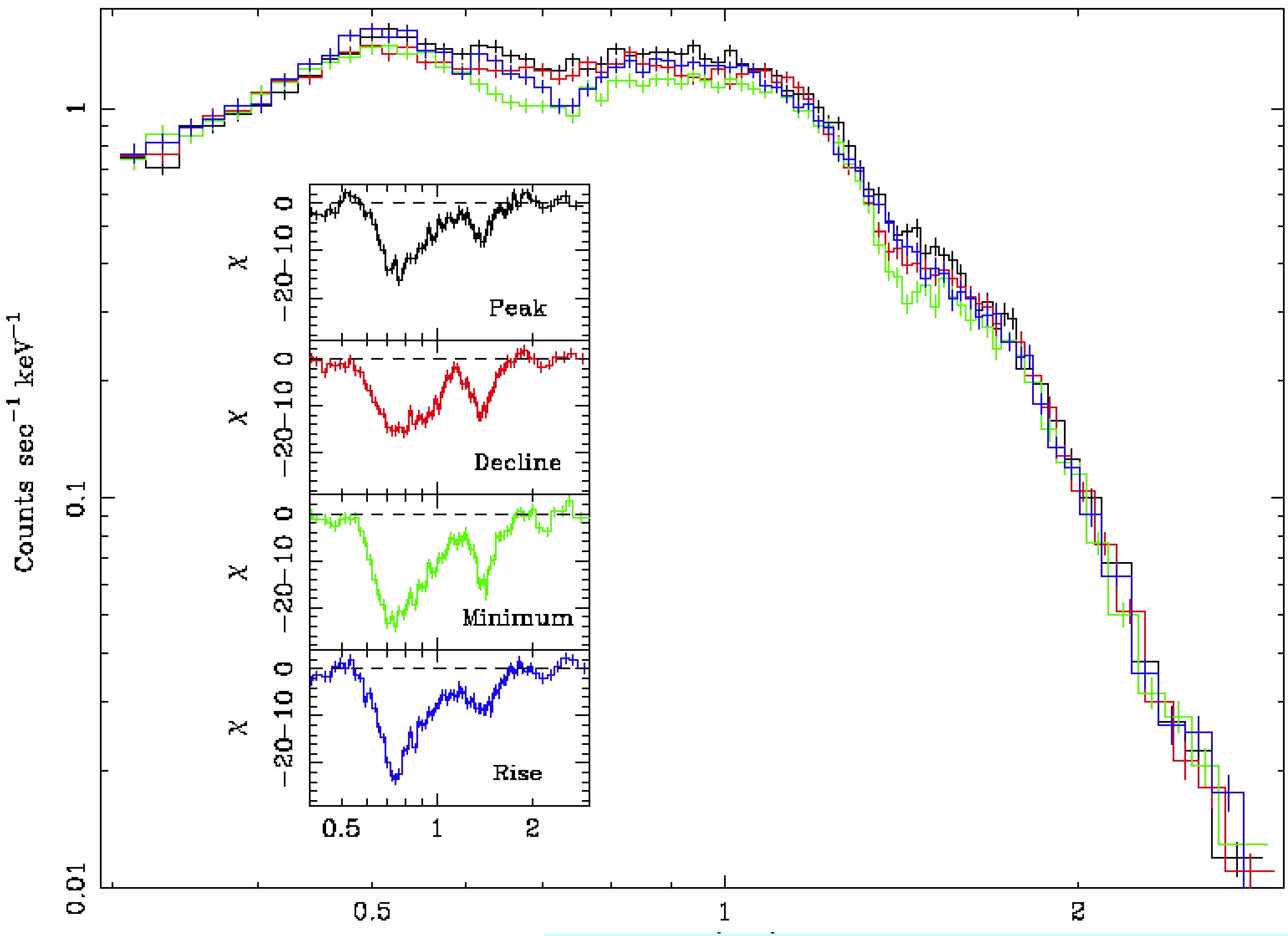
Magnetars & Disks

Table 1. Observational Constraints

Constraint	Value	Magnetars	Disks
Spin Period Distribution	Clustered around 5-10 s	No	Yes
Spin-Down Rates & Ages	$P/2\dot{P} \neq$ SNR Age	No	Yes
Braking Indices	$\neq 3$	No	Yes
Spin-Down Noise	Larger than in Pulsars	??	Yes
Located in Dense ISM	Opposite than for Pulsars	No	Yes
Visibility of Accretion Disk	Very small if at all	Yes	??
Number of Objects	~ 10	??	Yes
Normal Burst Energy	$\sim 10^{41}$ergs	Yes	Yes
Super Burst Energy	$\sim 10^{44}$ergs	Yes	Yes
Burst Durations	~ 0.2s	Yes	Yes
Abrupt Changes in $\dot{P}$	$\Delta\dot{P}/P \approx 1$	No	Yes
Change in Pulse Profile	Simplified at Superburst	Yes	??

Mereghetti et al.02

CYCLOTRON ABSORPTION LINES



Bignami et al. 2003,Nature 423,725

强磁场中的朗道能级

$$E_0 = \hbar\omega = \hbar\frac{eB}{m_e c} = 0.511(\frac{B}{B_q})\ \text{MeV}$$

$$B_q = 4.414 \text{ X } 10^{13}\ \text{高斯}$$

$$Z = \frac{GM}{c^2 R} \qquad Z = \frac{\lambda - \lambda_0}{\lambda_0} = \frac{E_0 - E}{E}$$

$$E = \frac{h\omega}{1+Z} = 10(\frac{B}{10^{12}\text{高斯}})(\frac{1.2}{1+Z})\ \text{KeV}$$

Spectrum line of AXP

Table 1. The AXPs and their associated SNRs

SOURCE	P (s)	$\dot{P}$ (s s^{-1})	SNR	$P/2\dot{P}$ (years)	B$^{(a)}$ (Gauss)	SNR age (kyr)	L$_x^{(b)}$ (erg s^{-1})	D$^{(c)}$ (kpc)
1E 2259+586	6.98	4.88×10^{-13}	G 109.1–0.1 (CTB 109)	227,000	6.1×10^{13}	3 –17	10^{35}	4
1E 1048.1–5937	6.45	(1.5-4)$\times10^{-11}$	–	$(3-7)\times10^{3}$	3.2×10^{14}	–	3.4×10^{34}	5
4U 0142+61	8.69	1.98×10^{-12}	–	70,000	1.4×10^{14}	–	3.3×10^{34}	1
1RXS J1708–4009	11.00	1.9×10^{-11}	–	9,200	4.8×10^{14}	–	6.8×10^{35}	8
1E 1841–045	11.77	4.16×10^{-11}	G 27.4+0.0	4,500	7.3×10^{14}	$\lesssim 3$	2.3×10^{35}	7
AX J1845.0 *(AXP cand*								

Line: **8.1 keV(astrph/0302490, 0309402)**

electron:B= 9 × 10^{11} G,

proton: B=1.6 × 10^{15} G

7

CCO & DRQNS

Compact Central Objects in SNRs

SOURCE	P (s)	$\dot{P}$ (s s^{-1})	L_x (erg s^{-1})	kT_{BB} (keV)	d (kpc)	Comments and references
RX J0822–4300	–	–	4.7×10^{33}	0.38	2	in Puppis A (2,9,10)
AX J0851.9–4617.4	–	–	9.1×10^{32}	0.4	2	in G266.1-1.2 (2,11,12)
1E 1207.4–5209	0.424	$(2^{+1.1}_{-1.3}) \times 10^{-14}$	9.5×10^{32}	0.27	2.1	in G296.5+10 (2,13,14)
1E 161348–5055.1	–	–	$(2.1 - 100) \times 10^{33}$	0.6	3.3	in RCW 103 (2,15)
CXO J232327.8+584842	–	–	3.4×10^{33}	0.7	3.4	in Cas A (2,16,17,18)

Line: **0 .7, 1.4 and 2.1 keV** (Bignami et al.Nature,2003)

Electron: $B_{p,dp/dt}=3\times10^{12}$G,(Xu et al.2003)

proton: $B_l=1.6 \times 10^{14}$ G (Sanwal et al. 2002)

RX J0420.0–						
RX J0720.4–						
RX J0806.4–						
RX J1308.8+2127	5.16	$(1.35 \pm 0.7) \times 10^{-11}$	5.1×10^{30}	0.118	0.1	RBS 1223 (3,22,23)
RX J						
RX J						
RX J						
1RXS	–	–				

B_12=E(kev)(1+z)/11.6 m/m_e

Test of observations

- ✦ **NS: different B**

  B: obs. ?**(Sanwal et al. 2002; Xu et al.2002)**

- ♠ **Disk: Observed ?**

  Near-IR obs. & Opt obs. (Hullemant et al.2000,2002)

  Disk: precession?**(Qiao et al,2003)**

- ♠ **NS or Strange star ?**

  SGR: disk+cloud **(Xu et al.2001)**

具有强磁场的射电脉冲星

- PSR B0154+61 (*B*= 2.1X10^13 G)
- PSR J1119-6127 (*B*= 4.4X10^13 G)
- PSR J1814_1744, *B* (5.5X10^13 G)
- PSR J1847-0130 (*B* = 9.4X10^13 G),

  X-ray emission was much lower than those of known AXPs

Pulsars with High-B

	PSR J1119–6127	PSR J1814–1744
Spin period, P (s)	0.40763747736(2)	3.975831061(5)
Period derivative, $\dot{P}$	$4.022602(2) \times 10^{-12}$	$7.4297(6) \times 10^{-13}$
Surface magnetic field, B (Gauss)	4.1×10^{13}	5.5×10^{13}
Characteristic age, τ_c (kyr)	1.6	85
Spin-down luminosity, $\dot{E}$ (erg s^{-1})	2.3×10^{36}	4.7×10^{32}
Braking index, n	2.91(1)	...
Distance, d (kpc)	2.4–8	10(2)
Radio luminosity, Sd^2 (mJy kpc^2)	~ 25	~ 80
Galactic longitude, l (deg)	292.15	13.02
Galactic latitude, b (deg)	–0.54	–0.21

Camilo et al.2000,ApJ

PSR(1814-1744)--AXP(2259+586)

Parameters	PSR J1814-1744	1E 2259+586
P(s)	4.0	7.0
P_{dot} (s/s)	$7.4 \sim 10^{-13}$	$4.9 \sim 10^{-13}$
B (G)	$5.5 \sim 10^{13}$	$5.9 \sim 10^{13}$
◆= /(2P_{dot}) (kyr)	85	230
E_{dot} (erg/s)	$4.7 \sim 10^{32}$	$5.7 \sim 10^{31}$

$B_{radio} \approx B_{AXP}$

Table 9. Pulsars of Type AXP, HE or NR

Name	J2000 Name	Period (s)	Age (yr)	B_s (G)	Association
Radio pulsars having high-energy pulsations (Type HE):					
J0205+6449	J0205+6449	0.065686	5.37e+03	3.61e+12	SNR:3C58
J0218+4232	J0218+4232	0.002323	4.76e+08	4.29e+08	···
J0437−4715	J0437−4715	0.005757	1.59e+09	5.81e+08	···
B0531+21	J0534+2200	0.033085	1.24e+03	3.78e+12	SNR:Crab[ccl+69]
B0540−69	J0540−6919	0.050354	1.67e+03	4.97e+12	EXGAL:LMC,SNR:0540−693
B0656+14	J0659+1414	0.384891	1.11e+05	4.66e+12	SNR:Monogem_Ring[tbb+03]
B0823+26	J0826+2637	0.530661	4.92e+06	9.64e+11	···
B0833−45	J0835−4510	0.089328	1.13e+04	3.38e+12	SNR:Vela
B0950+08	J0953+0755	0.253065	1.75e+07	2.44e+11	···
B1046−58	J1048−5832	0.123671	2.03e+04	3.49e+12	···
B1055−52	J1057−5226	0.197108	5.35e+05	1.09e+12	···
J1105−6107	J1105−6107	0.063193	6.33e+04	1.01e+12	···
J1124−5916	J1124−5916	0.135314	2.87e+03	1.02e+13	SNR:G292.0+1.8
B1509−58	J1513−5908	0.150658	1.55e+03	1.54e+13	SNR:G320.4−1.2
J1617−5055	J1617−5055	0.069357	8.13e+03	3.10e+12	···
B1706−44	J1709−4429	0.102459	1.75e+04	3.12e+12	SNR:G343.1−2.3(?)[mop93]
B1800−21	J1803−2137	0.133617	1.58e+04	4.28e+12	SNR:G8.7−0.1(?)[kw90]
B1821−24	J1824−2452	0.003054	2.99e+07	2.25e+09	GC:M28
B1823−13	J1826−1334	0.101466	2.14e+04	2.79e+12	···
J1930+1852	J1930+1852	0.136855	2.89e+03	1.03e+13	SNR:G54.1+0.3
B1929+10	J1932+1059	0.226518	3.10e+06	5.18e+11	···
B1937+21	J1939+2134	0.001558	2.35e+08	4.09e+08	···
B1951+32	J1952+3252	0.039531	1.07e+05	4.86e+11	SNR:CTB80
J2124−3358	J2124−3358	0.004931	3.80e+09	3.22e+08	···
J2229+6114	J2229+6114	0.051624	1.05e+04	2.03e+12	···

Optical Observations of AXP

Table 1. The AXPs and their associated SNRs

SOURCE	P (s)	$\dot{P}$ (s s^{-1})	SNR	$P/2\dot{P}$ (years)	B[(a)] (Gauss)	SNR age (kyr)	$L_x^{(b)}$ (erg s^{-1})	D[(c)] (kpc)
1E 2259+586	6.98	4.88×10^{-13}	G 109.1–0.1 (CTB 109)	227,000	6.1×10^{13}	3 –17	10^{35}	4
1E 1048.1–5937	6.45	$(1.5\text{-}4)\times10^{-11}$	–	$(3-7) \times 10^{3}$	3.2×10^{14}	–	3.4×10^{34}	5
4U 0142+61	8.69	1.98×10^{-12}	–	70,000	1.4×10^{14}	–	3.3×10^{34}	1
1RXS J1708–4009	11.00	1.9×10^{-11}	–	9,200	4.8×10^{14}	–	6.8×10^{35}	8
1E 1841–045	11.77	4.16×10^{-11}	G 27.4+0.0 (Kes 73)	4,500	7.3×10^{14}	$\lesssim 3$	2.3×10^{35}	7
AX J1845.0–0300 *(AXP candidate)*	6.97	–	G 29.6+0.1					

Opt. Observation

Hulleman,et al. Nature,2002,,(2259)

Hulleman,et al Nature, 2000(0142)

IR Observations of AXP

Table 1. The AXPs and their associated SNRs

SOURCE	P (s)	$\dot{P}$ (s s^{-1})	SNR	$P/2\dot{P}$ (years)	B[(a)] (Gauss)	SNR age (kyr)	$L_x^{(b)}$ (erg s^{-1})	D[(c)] (kpc)
1E 2259+586	6.98	4.88×10^{-13}	G 109.1–0.1 (CTB 109)	227,000	6.1×10^{13}	3 –17	10^{35}	4
1E 1048.1−5937	6.45	$(1.5\text{-}4) \times 10^{-11}$	–	$(3-7) \times 10^3$	3.2×10^{14}	–	3.4×10^{34}	5
4U 0142+61	8.69	1.98×10^{-12}	–	70,000	1.4×10^{14}	–	3.3×10^{34}	1
1RXS J1708−4009	11.00	1.9×10^{-11}	–	9,200	4.8×10^{14}	–	6.8×10^{35}	8
1E 1841−045	11.77	4.16×10^{-11}	G 27.4+0.0 (Kes 73)	4,500	7.3×10^{14}	$\lesssim 3$	2.3×10^{35}	7
AX J1845.0−0300 *(AXP candidate)*	6.97	–	[illegible]	[illegible]	[illegible]	[illegible]	$10^{34(d)}$	8

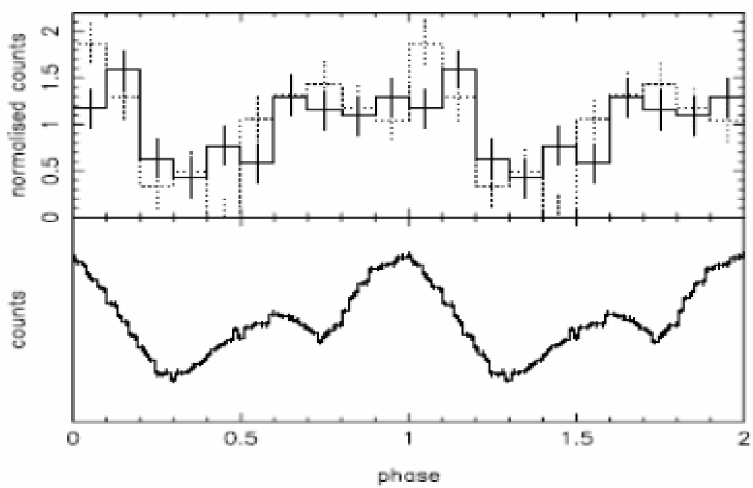
IR Observation

astroph/0204233(1708)
astroph/0209599(1048)
Hulleman,et al. ApJ,2001,(2259)
Hulleman,et al 2000(0142)

Optical

- pulsations with high pulse fraction (higher than X-rays)
- (wrongly) used as argument against disk models

12 *V. S. Dhillon et al.* **4U 0142+614**



ure 2. Top: pulse profiles of 4U 0142+61 in the i' band on 2002 ptember 12 (solid line), obtained using technique (i) (Section 2.1). The

optical (i' band)

X-rays

L114 *V. S. Dhillon et al.* **1E 1048-59**

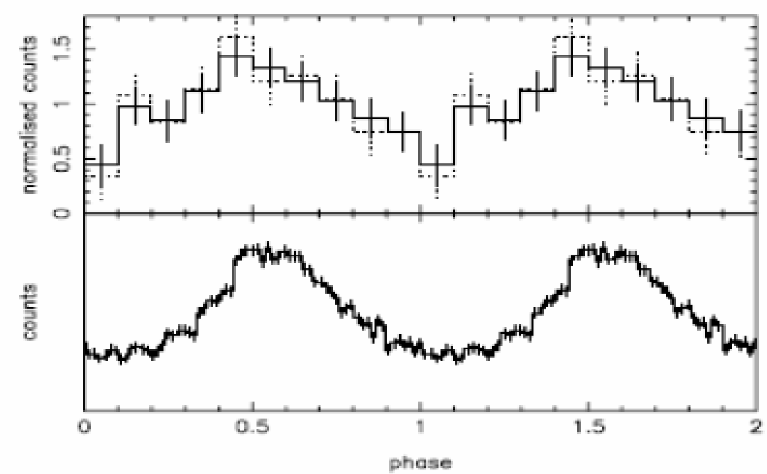


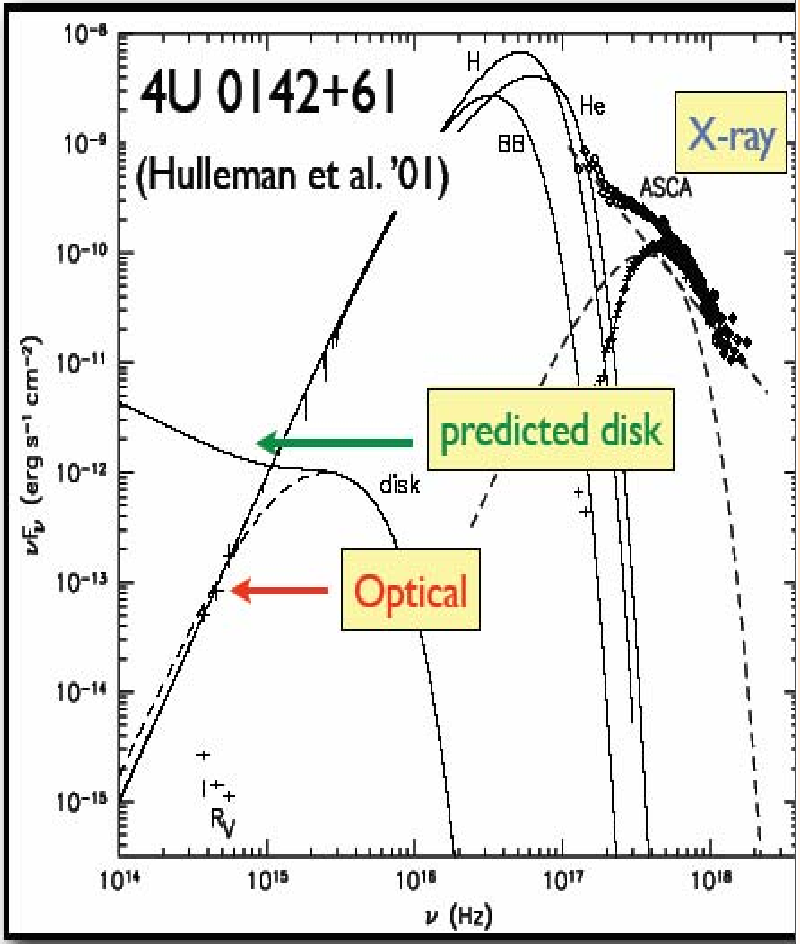
Figure 2. Top: the solid and dotted lines show optical pulse profiles of 1E 1048.1−5937 in the i' band obtained using techniques (i) and (ii), re-

- Accretion invoked to explain luminosity: $L_x \gg \dot{E}$ and narrow range of spin periods

  (van Paradijs et al. '95; Ghosh et al. '97; Corbet et al. '95; Chatterjee et al. '99; Alpar '01; Marsden et al. '01 and others)

- Basic model: like LMXB disk, but no outer edge, so radiates into IR (Perna et al. '00)

- Ruled out for AXPs & SGRs: observed O/IR flux (or limits) inconsistent with disk of size needed to power X-rays (Hulleman et al. '00, '01; Kaplan et al. '01)



Kapla 2009

X-ray emission of Pulsars

PSR J	Pulsed Radiation	log L_{400}	log L_{1400}	log L_x	$\dot{E}$ (erg/s)	SNR	Type	L_{tot} 10^{35} (erg/s)	d (kpc)	D (pc)	n
0534+2200	R, O, X, γ	3.41	1.75	36.0	38.6	Crab	F	1.8	2	3.5	2.5
0540-6919	R, O, X, γ	3.24		36.2	38.2	N157B	F	3.5	50	24	2.2
0835-4510	R, O, γ	3.1	2.31	32.6	36.8	Vela	C	0.15	0.45	32	1.4
1119-6127	R		1.70		36.4	G292.2-05	S	0.15	7.5	16	2.9
1513-5908	R, O, X, γ	1.55	1.25	34.3	37.2	RCW 89	C	0.46	4.2	42	2.84

X 射线脉冲星和磁星

1、 what is the “Magnetar”?

AXP: Anomalous X-ray Pulsars

SGR: Soft Gamma-ray Repeaters

Radio Pulsars; X-ray Pulsars

2、AXP模型 & 观测检验

3、AXP 的射电观测

4、 “*Magnetar*” *or* “Quarcstar”

“磁星”的射电观测

Table 5. Upper limits on radio emission at 1.4 GHz

SOURCE	5σ u.l. (mJy)	References
1E 2259+586	0.083	Coe et al. (1994)
1E 1048.1−5937	0.07[a]	Israel et al. (2002)
	0.13[a]	Crawford et al. (2002)
4U 0142+61	0.27	Gaensler et al. (2001)
1RXS J1708−4009	3	Gaensler et al. (2001)
	0.07[a]	Israel et al. (2002)
	0.22[a]	Crawford et al. (2002)
1E 1841−045	0.6	Kriss et al. (1985)
	0.07[a]	Israel et al. (2002)
	0.25[a]	Crawford et al. (2002)
AX J1845.0−0300	0.07[a]	Israel et al. (2002)
	0.13[a]	Crawford et al. (2002)

SGR 观测特征

	Radio Counterpart	NIR Counterpart	X-ray Counterpart	Host	Progenitor
SGR1806-20	After giant flare (transient)	Yes	Yes	Massive star cluster?	$48M_{\odot}$
SGR1900+14	After giant flare (transient)	No	Yes	Massive star cluster?	Massive Star?
SGR0525-66	No	No	Yes	SNR	?
SGR1627-41	No	No	Yes	CTB33?	?
SGR0501+45	No	Maybe	Yes	SNR?	?
1E1547-5408	Yes	Yes	Yes	SNR	?

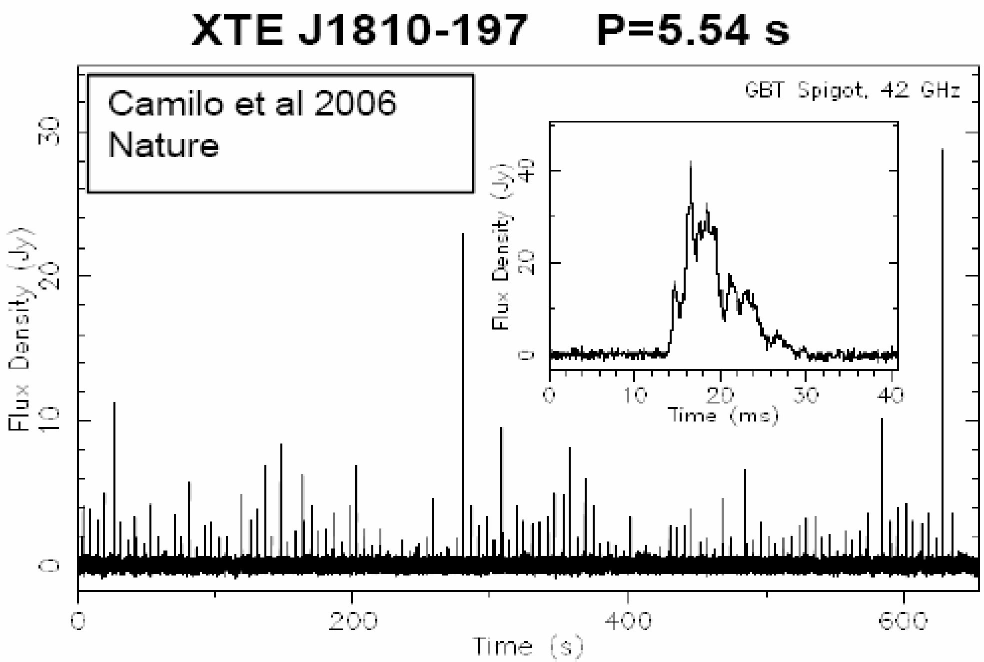
NAME	P (s)		RADIO	IR	OPTICAL	X SOFT	X HARD
CXO J0110-72	8.0	SMC				P	
4U 0142+61	8.7			D	P	P	P
1E 1048-59	6.4			D	P	P	D
1E 1547-54	2.1	G327.24-0.13	P	D		P T	
CXO J647-45	10.6	Westerlund 1		NEW		P T	
RXS 1708-40	11.0			D?		P	P
XTE J1810-197	5.5		P	D		PT	
1E 1841-045	11.8	Kes 73		D?		P	P
AX J1845-02	7.0	G29.6+0.1				P T	
1E 2259+586	7.0	CTB 109	NEW			P	
SGR 0501+45	5.7		T	D		P T	P
SGR 0526-66	8	LMC , N49				P	
SGR 1627-41	2.6	NEW				P T	
SGR 1806-20	7.6	Star cluster	T	D		P	D
SGR 1900+14	5.2	Star cluster	T	D?		P	D

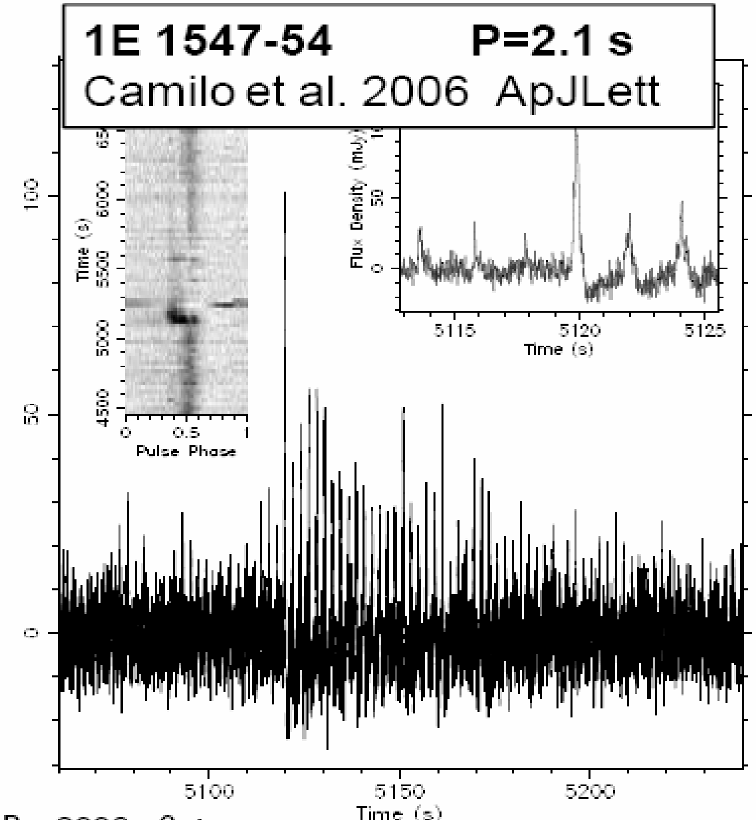
Radio (unpulsed)

- Transient emission after (Giant) Flares
- Seen in two SGRs, but possibly present in all bright flares

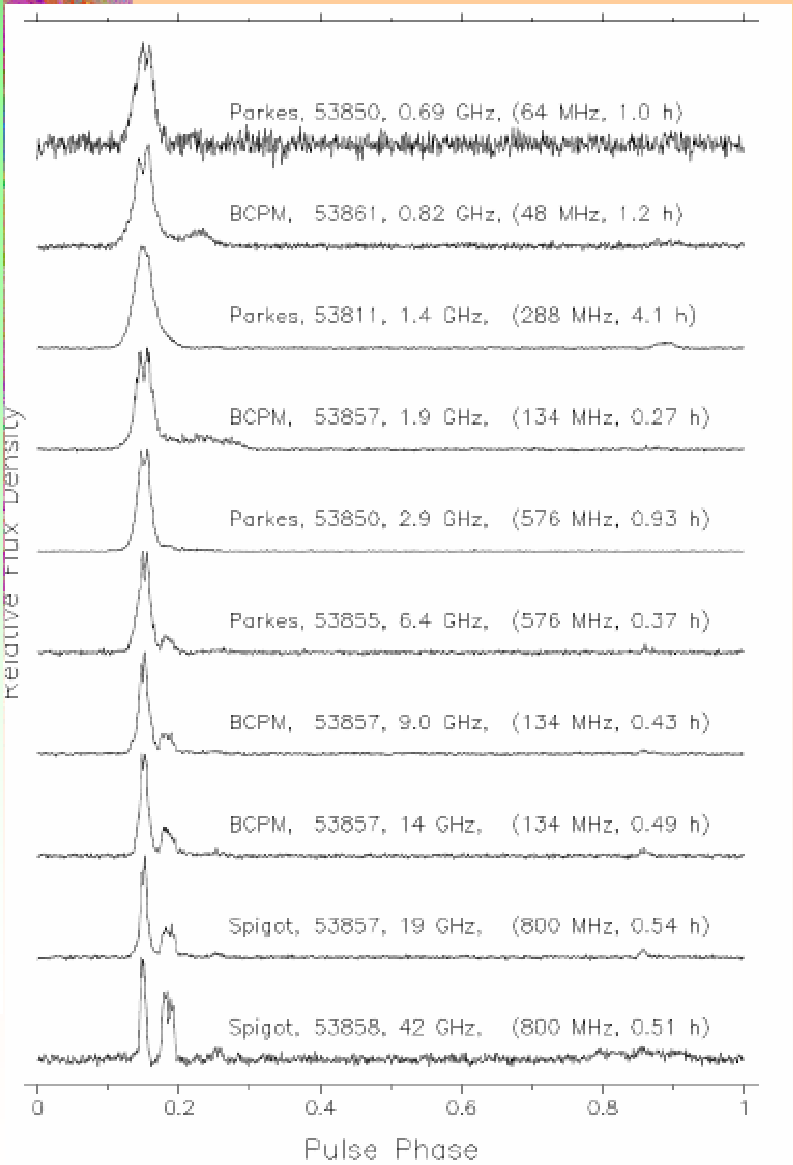
Radio (pulsed)

- seen in two (transient) AXPs
- absence in other ~10 consistent with beaming





XTE J1810–197 : a transient AXP(2003)



P = 5.54 s
Pdot = 1.016 × 10^-11

Camilo at al. astro-ph/0605429

Polarization: AXP J1810−197

Kramer et al.2007

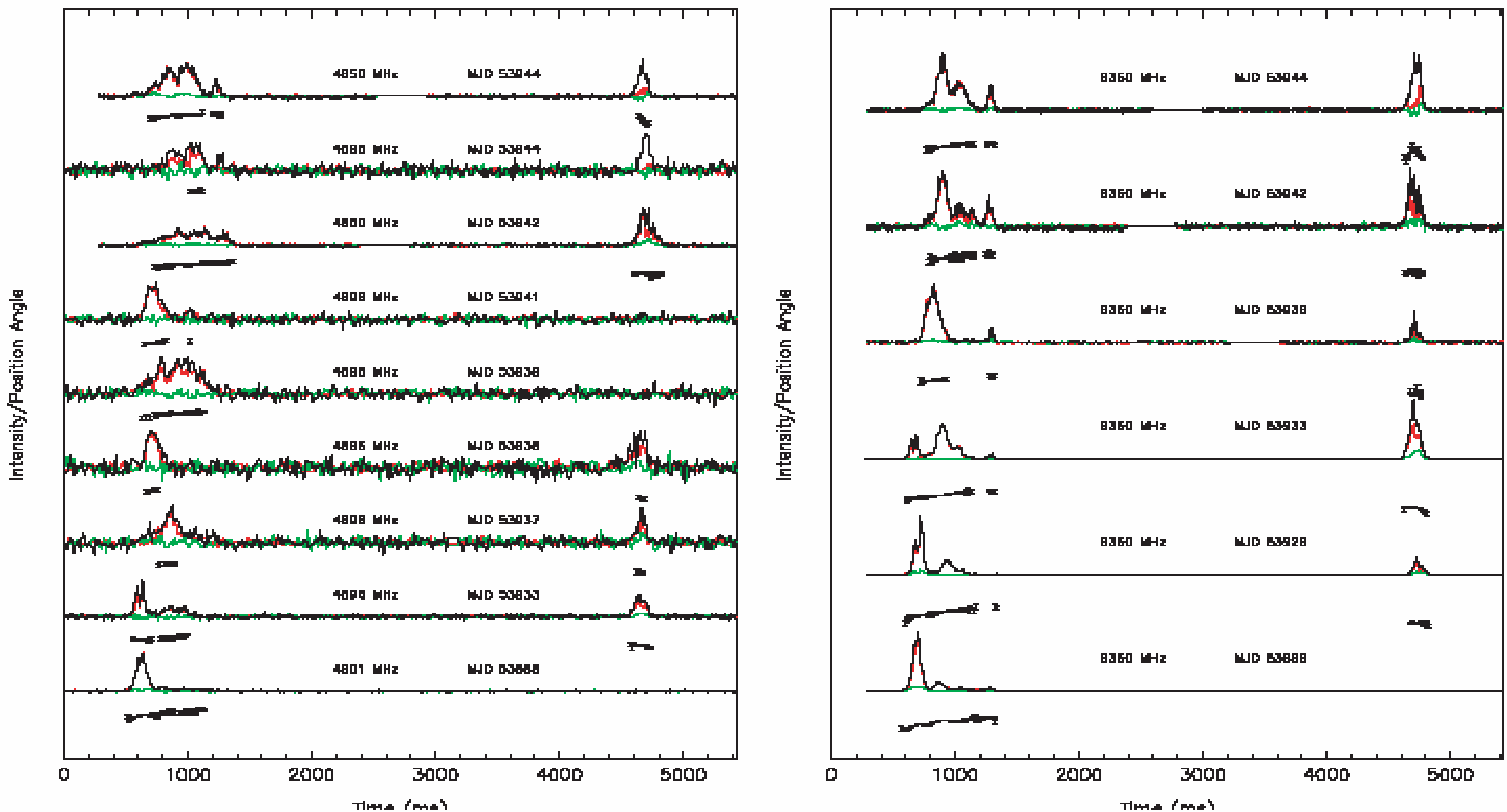


Figure 4. Comparison of the average pulse profiles in full polarization observed over several weeks at 4.9 and 8.4 GHz. Total power (black) and linearly (red) and circularly (green) polarized power are shown together with the measured position angle for each epoch and frequency. The scale of the shown position angle swing is again identical for all pulse profiles of a given epoch and is presented here only to allow for a comparison of its general shape and extent. A quantitative comparison is made in Figs 7 and 8.

The polarization : 80–95%

Transient pulsed radio emission from a magnetar: XTE J1810–197

Camilo et al.2006

- a point-like radio source of unknown origin **one year** after the X-ray outburst

$P = 5.54024870$ s $\pm$ 20 ns on MJD 53855.0

$Pdot = (1.016 \pm 0.001) \times 10^{-11}$

$D = 3.3$ kpc

- remarkable radio pulsations

---sharply modulated at the rotation period

---with peak flux density > 1 Jy and are

---highly linearly polarised,

Transient pulsed radio emission from a magnetar: XTE J1810–197 Camilo et al.2006

- In contrast to ordinary pulsars,

  ---there is no evidence of radio activity prior to the 2003 X-ray outburst, and

  ---the intrinsic flux varies on short timescales

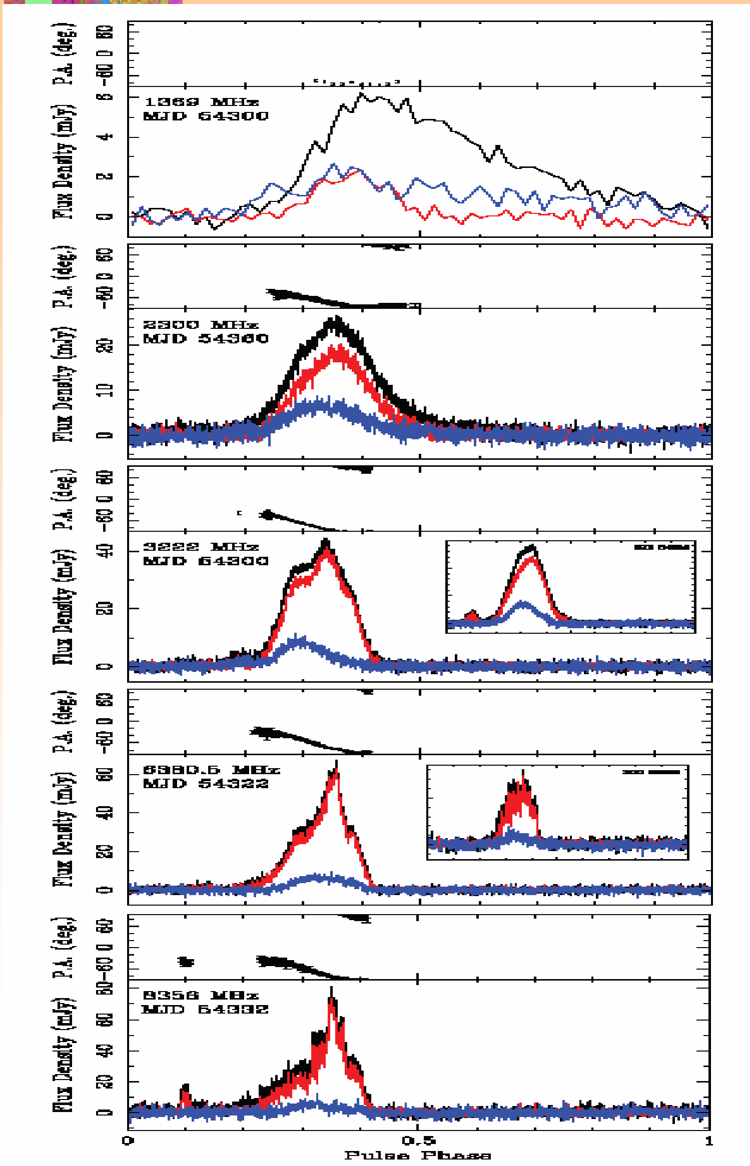
  ---flat spectrum, at > 20GHz, the brightest neutron star known.

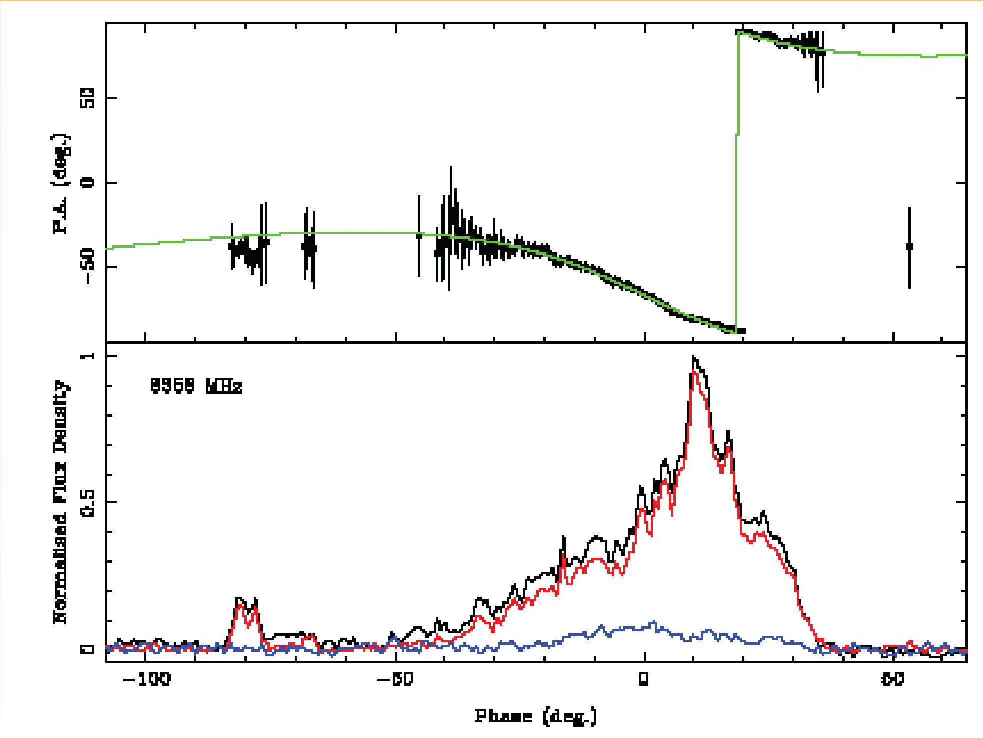
与通常的脉冲星比较

- **no radio** activity prior to the 2003 X-ray outburst,
- the intrinsic flux **vari**es on short timescales
- with an approximately **flat** spectrum ,
- at > 20GHz, is the **brightes**t neutron star known.

=>a **unique** opportunity to probe in detail the dynamic magnetosphere of a neutron star.

Transient AXP 1E 1547.05408(PSR J15505418)



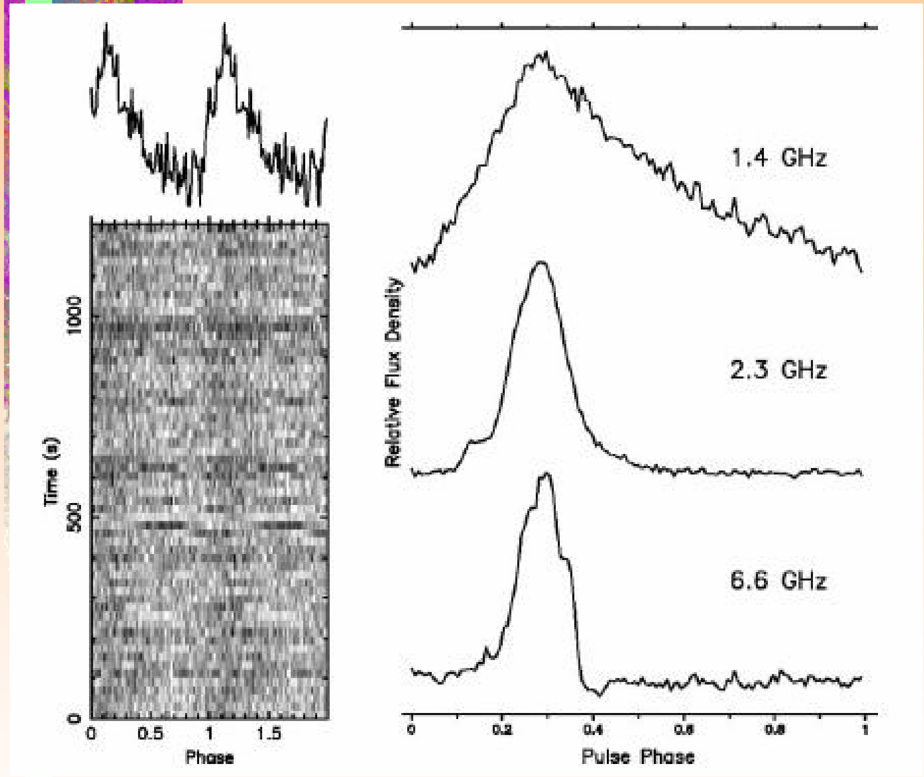


1.4–8.4 GHz.

8.4 GHz.

nearly 100% linearly polarized

1E 1547.0 - 5408



p = 2.069 s

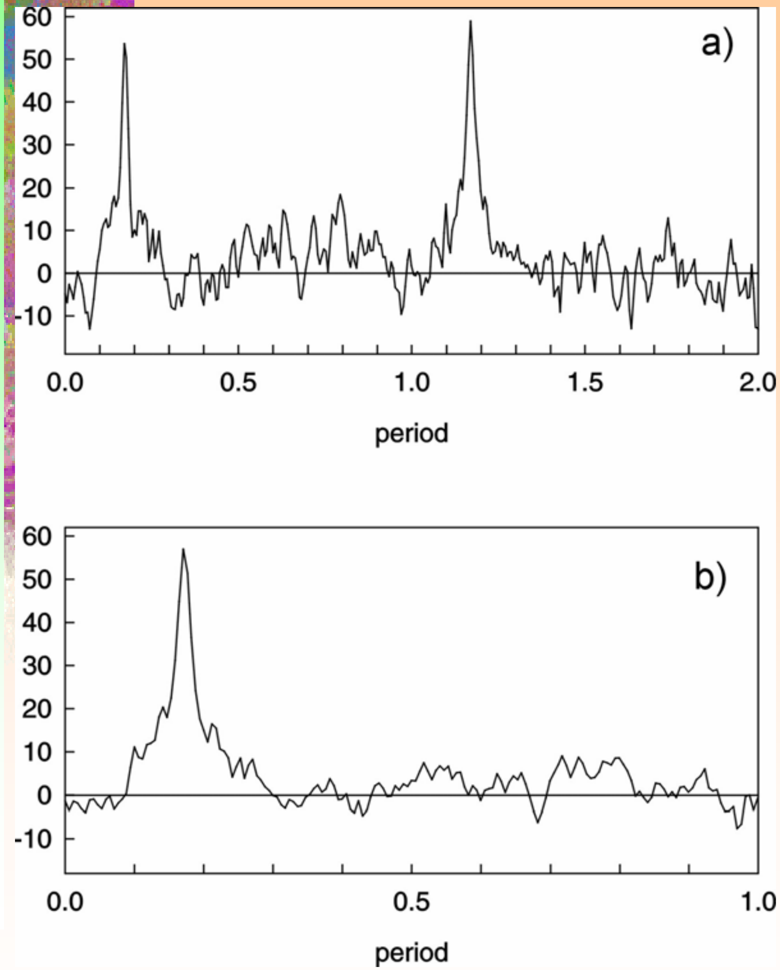
p’ = (2.318 $\pm$ 0.005)·10^{-11}

1.4GHz: ≈75% is pulsed

The variable X-ray source as a likely magnetar in G327.24–0.13, X-ray pulsations have been detected

Camilo et al., Astrophys.J, 666, 2007

AXP 4U 0142+61



111.23 MHz

Malofeev et al. 2009

Main problem

None of the AXPs and SGRs show the evidence of a binary companion : $E_{dot} < L_X$?

The most popular magnetar model of Thompson & Duncan (1996) proposes the enormous surface magnetic fields 10^{14} - 10^{15} G and the absence of radio emission from these objects (Baring & Harding 1998).

Malofeev et al. 2009

Acceretion & Magnetar ?
Radiation models?

- There is radio emission from AXP, SGR and XDINS at low radio frequencies.

- The discovery of radio emission from AXP*(Malofeev et al. 2001, 2005, 2007)*, SGR *(Shitov et al. 2000)* together with the detection of transient pulsed radio emission from AXP XTE J1810-197, 1E 1547.0 - 5408 *(Camilo et al. 2006, 2007)* gives a reason to revise either the radio emission mechanisms in the “magnetar” model or the “magnetar” model itself.

Malofeev et al. 2009

X 射线脉冲星和磁星

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SGR & AXP : Magnetars or Quark Stars?

age crisis :

spin-down ages of SGRs << ages of SNR

separation crisis

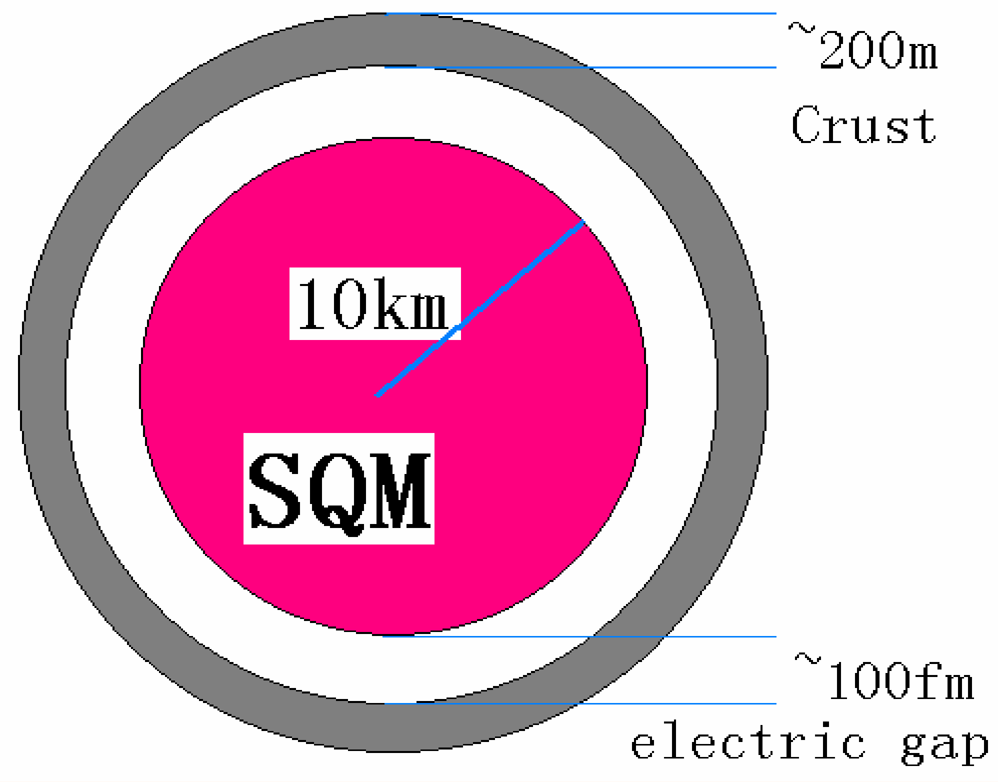
The location of SGRs move with large velocities

energy crisis

Sudden increases in P require jumps in the energy stored by the magnetic field

Arnon Dar and A. De R´ ujula/ astro-ph/0002014

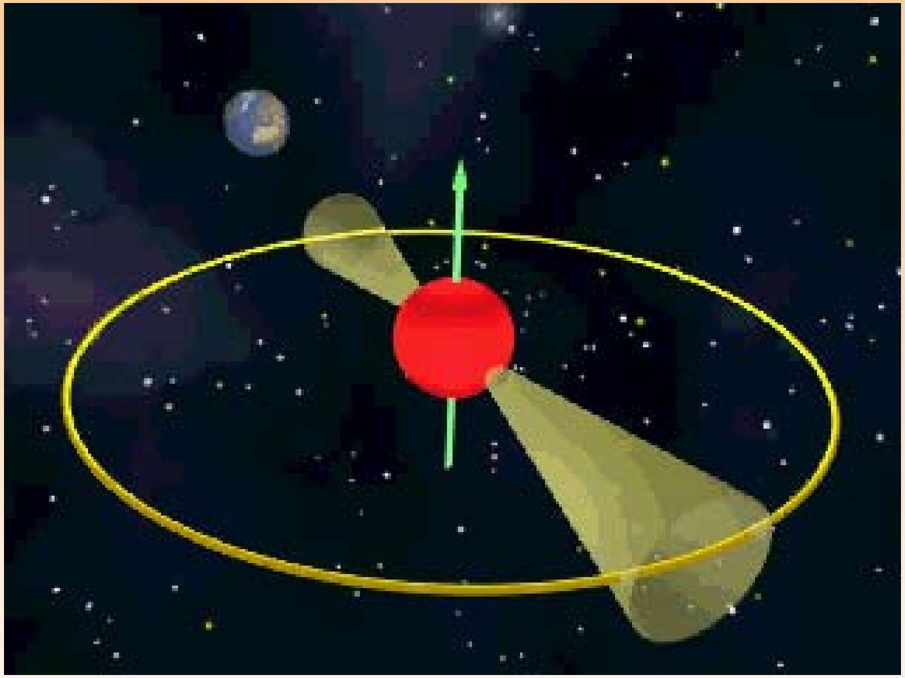
SGR & AXP : Magnetars or Quark Stars?

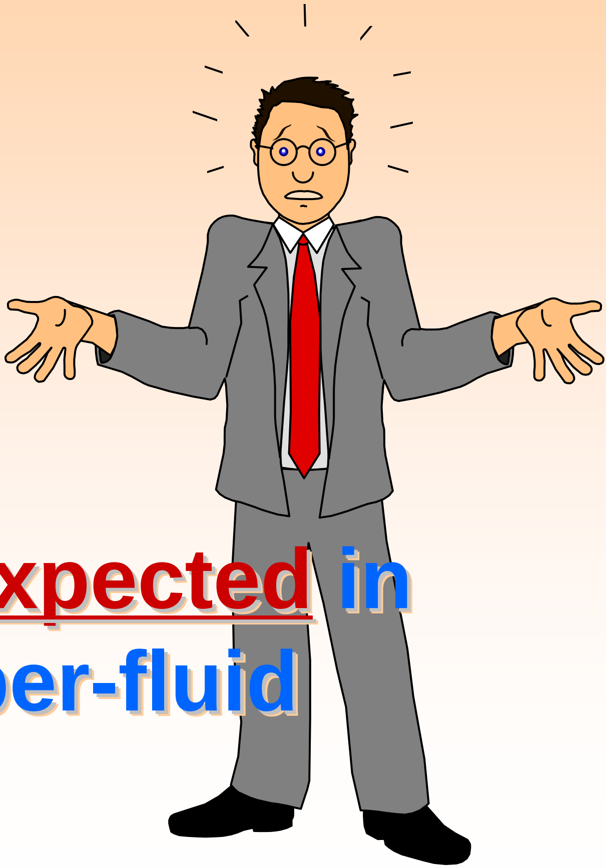


$M_{crust} \approx 10^{-5} M_{sun}$ --- $10^{-4} M_{sun}$

谢谢！

Free Precession of a Radio Pulsar





BUT: Free precession is **not expected** in case of pinned vortices in super-fluid interior!

Fallback Disk --> precession?

An accretion disk model for periodic timing variations of pulsars (Qiao et al. 2003, A&A407,L25)