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# ANOMALOUS X-RAY PULSARS AND SOFT GAMMA-RAY REPEATERS IN THE OUTER GAP MODEL: CONFRONTING *FERMI* OBSERVATIONS

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## ABSTRACT

Anomalous X-ray pulsars (AXPs) and soft gamma-ray repeaters (SGRs) are magnetar candidates, i.e., neutron stars powered by a strong magnetic field. If they are indeed magnetars, they will emit high-energy gamma rays that are detectable by the *Fermi* Large Area Telescope (LAT), according to the outer gap model. However, no significant detection is reported in recent *Fermi*-LAT observations of all known AXPs and SGRs. Considering the discrepancy between theory and observations, we calculate the theoretical spectra for all AXPs and SGRs with sufficient observational parameters. Our results show that most AXPs and SGRs are high-energy gamma-ray emitters if they are really magnetars. The four AXPs 1E 1547.0−5408, XTE J1810−197, 1E 1048.1−5937, and 4U 0142+61 should have been detected by *Fermi*-LAT. There is therefore a conflict between the outer gap model in the case of magnetars and *Fermi* observations. Possible explanations in the magnetar model are discussed. On the other hand, if AXPs and SGRs are fallback disk systems, i.e., accretion-powered for the persistent emissions, most of them are not high-energy gamma-ray emitters. Future deep *Fermi*-LAT observations of AXPs and SGRs will help us make clear whether they are magnetars or fallback disk systems.

*Key words:* gamma rays: stars – pulsars: general – radiation mechanisms: non-thermal – stars: magnetars – stars: neutron

*Online-only material:* color figures

## 1. INTRODUCTION

Anomalous X-ray pulsars (AXPs) and soft gamma-ray repeaters (SGRs) are two peculiar kinds of pulsar-like objects. Their persistent X-ray luminosities are in excess of their rotational energy loss rates, while at the same time they show no binary signature (Mereghetti 2008). They also show recurrent SGR-type bursts (Hurley 2009). Therefore, the energy budget of AXPs and SGRs is a fundamental problem in their studies. They are supposed to be magnetic field powered, i.e., magnetars (Thompson & Duncan 1995, 1996). Another possibility is that they are accretion-powered systems, i.e., accretion from supernova fallback disks (Alpar 2001; Chatterjee et al. 2000; Xu et al. 2006). As such, it is of fundamental importance to determine whether they are magnetars or fallback disk systems. Solving this problem is also helpful for other high-energy astrophysical phenomena and related pulsar-like objects (Xu 2007; Tong et al. 2010b).

Cheng & Zhang (2001) proposed that although AXPs are slowly rotating neutron stars, if their surface dipole magnetic field is strong enough (i.e., if they are really magnetars) then they can accelerate particles and emit high-energy gamma rays that are detectable by the *Fermi* Large Area Telescope (LAT) according to the outer gap model (Zhang & Cheng 1997). However, Sasmaz Mus & Gogus (2010) reported a non-detection in a *Fermi*-LAT observation of AXP 4U 0142+61. This observation is in conflict with the outer gap model. Tong et al. (2010a) proposed that *Fermi*-LAT observations can help us distinguish between the magnetar model and the fallback disk model. Recently, the *Fermi*-LAT collaboration has published its observations for all known AXPs and SGRs (five SGRs and eight AXPs), in which no significant detection is reported (Abdo et al. 2010b). Considering this discrepancy between theory and observations, a comprehensive study of this issue is necessary.

In Cheng & Zhang (2001), only five AXPs are considered, and the parameters they used are very uncertain, e.g., the surface temperatures are estimated from the X-ray luminosities, etc. Now, we have very good observational data for more sources (see the McGill AXP/SGR online catalog[3]). There are also developments of the outer gap model (e.g., Takata et al. 2010). In this paper, with up-to-date observational parameters of AXPs and SGRs, we consider the high-energy gamma-ray radiation properties of AXPs and SGRs in the outer gap model (Zhang & Cheng 1997; Takata et al. 2010) and compare them with *Fermi*-LAT observations.

Section 2 presents an application of self-consistent outer gaps to AXPs and SGRs. We consider both the magnetar model and the fallback disk model. Discussions and conclusions are presented in Sections 3 and 4, respectively.

## 2. APPLICATION OF SELF-CONSISTENT OUTER GAPS TO AXPs AND SGRs

The outer gap is very successful in explaining pulsar high-energy emissions (Cheng et al. 1986; Cheng 2009). Zhang & Cheng (1997) developed the self-consistent outer gap model in which the longitudinal extension of the outer gap is determined self-consistently by the $\gamma - \gamma$ pair production process. If the X-ray photons are provided by neutron star surface thermal emission, the size of the outer gap is (Zhang & Cheng 1997)

$$f_{\gamma\gamma} = 4.5 P^{7/6} B_{12}^{-1/2} T_6^{-2/3} R_6^{-3/2}, \quad (1)$$

where $P$ is the neutron star rotation period, $B_{12}$ is the surface magnetic field in units of $10^{12}$ G, $T_6$ is the surface temperature in units of $10^6$ K, and $R_6$ is the neutron star radius in units of

[3] http://www.physics.mcgill.ca/~pulsar/magnetar/main.html), up to 2011 February 9.

**Table 1**
Size of the Outer Gap for 3 SGRs and 10 AXPs

| Source | $P$ (s) | $\dot{P}$ ($10^{-11}$) | $T_{\rm BB}$ (keV) | $d$ (kpc) | $f_{\gamma\gamma}$[a] | $f_{\rm m}$ | Detectability |
|---|---|---|---|---|---|---|---|
| SGR 1806−20 | 7.6022 | 75 | 0.6 | 8.7 | 0.14 (0.19) | 1.54 | No |
| SGR 1900+14 | 5.1999 | 9.2 | 0.47 | 13.5[b] | 0.20 (0.27) | 1.27 | No |
| SGR 0501+4516 | 5.7621 | 0.582 | 0.69 | 5.0 | 0.34 (0.45) | 1.34 | No |
| 1E 1547.0−5408 | 2.0698 | 2.318 | 0.43 | 3.9 | 0.13 (0.17) | 0.80 | Yes |
| XTE J1810−197 | 5.5404 | 0.777 | 0.301[c] | 3.5 | 0.54 (0.70) | 1.32 | Yes |
| 1E 1048.1−5937 | 6.4521 | 2.70 | 0.623 | 2.7 | 0.28 (0.37) | 1.42 | Yes |
| 1E 2259+586 | 6.9789 | 0.048 | 0.411 | 4.0 | 1.1 (1.4) | 1.48 | Never |
| 4U 0142+61 | 8.6883 | 0.196 | 0.395 | 2.5[d] | 0.95 (1.3) | 1.65 | Yes |
| CXO J164710.2−455216 | 10.6107 | 0.24 | 0.63 | 5 | 0.80 (1.05) | 1.82 | No |
| 1RXS J170849.0−400910 | 10.999 | 1.945 | 0.456 | 8 | 0.61 (0.80) | 1.85 | No |
| 1E 1841−045 | 11.775 | 4.1551 | 0.44 | 8.5 | 0.55 (0.72) | 1.92 | No |
| PSR J1622−4950 | 4.3261 | 1.7 | 0.4 | 9 | 0.29 (0.38) | 1.16 | No |
| CXOU J171405.7−381031 | 3.8254 | 6.40 | 0.38 | 8 | 0.19 (0.25) | 1.09 | Marginal |

**Notes.** Columns 1–8 are source name, period, period derivative, surface temperature, distance, size of outer gap $f_{\gamma\gamma}$, size of outer gap $f_{\rm m}$, and detectability by *Fermi*-LAT for one-year exposure time. The two candidate AXPs, PSR J1622−4950 and CXOU J171405.7−381031, are also included. All data are from the McGill AXP/SGR catalog (except the distance data of SGR 0501+4516, which are from Abdo et al. 2010b and references therein).
[a] $f_{\gamma\gamma}$ when star radius $R = 12$ km ($R = 10$ km in brackets).
[b] Median value is employed.
[c] The temperature of the hotter component is employed.
[d] Lower limit is employed.

$10^6$ cm. Here, $f$ should be less than one for the outer gap to exist. Takata et al. (2010) further considered the $\gamma - {\rm B}$ pair production process as a gap closure mechanism. The size of the outer gap at half the light cylinder radius is (Takata et al. 2010)

$$f_{\rm m} = 2^{-3/2} \times 0.25\,{\rm K}(\chi, B_{\rm m}, s) P_{-1}^{1/2}, \qquad (2)$$

where $P_{-1}$ is the rotation period in units of 0.1 s, $K$ depends on the local geometry of magnetic fields at which the $\gamma - {\rm B}$ process takes place (Takata et al. 2010);

$$K = \chi_{-1}^2 B_{{\rm m},12}^{-2} s_7 (R/R_{\rm i})^{3/2}, \qquad (3)$$

where $\chi_{-1}$ is a dimensionless parameter in units of 0.1, which depends on the angle between the photon propagation direction and magnetic field, $B_{{\rm m},12}$ is the multipole field in units of $10^{12}$ G, $s_7$ is the local curvature radius in units $10^7$ cm, $R$ is the neutron star radius, and $R_{\rm i}$ is the radial distance at which the $\gamma - {\rm B}$ process takes place.

### 2.1. *Calculations in the Case of Magnetars*

With up-to-date observational parameters of AXPs and SGRs, we calculate the gamma-ray radiation properties of all AXPs and SGRs that have period, period derivative, surface temperature, and distance measurement (except one source in the Small Magellanic Cloud). Three SGRs and ten AXPs (including two candidates) are selected. The results are summarized in Table 1. The period, period derivative, surface temperature, and distance data are all from the McGill AXP/SGR catalog (except the distance data of SGR 0501+4516, which are from Abdo et al. 2010b and references therein). The magnetic field is calculated from $B = 6.4 \times 10^{19}\sqrt{P\dot{P}}$, which is two times larger than usually reported since the polar magnetic field is more important in the case of pulsar radiation (Shapiro & Teukolsky 1983). We consider the typical case with an inclination angle of 60° (Cheng & Zhang 2001). The solid angle is chosen as $\Delta\Omega = 1$. A star radius $R = 12$ km is employed, corresponding to medium to stiff equation of state. A medium to stiff equation of state is favored by the recently measured 2 solar-mass neutron star (Demorest et al. 2010).

For a magnetar whose surface magnetic field is about $10^{15}$ G, the $\gamma - {\rm B}$ pair production process will take place at about 10 stellar radius where the magnetic field is about $10^{12}$ G. Then, the $K$-parameter in Equation (2) is about 2. Since magnetars are slowly rotating neutron stars, the size of outer gap $f_{\rm m}$ will always be larger than one. Therefore, for magnetars, the gap closure mechanism will be dominated by the $\gamma - \gamma$ pair production process. This conclusion is depicted quantitatively in Table 1. From Table 1, we see that only for one AXP 1E 2259+586 is the size of the outer gap larger than one. Therefore, this AXP will not emit high-energy gamma rays. The rest of the AXPs and SGRs are all high-energy gamma-ray emitters according to the outer gap model (Zhang & Cheng 1997).

The theoretical spectra energy distributions (SEDs) are calculated following Zhang & Cheng (1997) and Cheng & Zhang (2001). The spectra of the three SGRs and nine AXPs (including two candidate AXPs) are shown in Figures 1 and 2, and are summarized in Table 1. We see that due to their large distances, the three SGRs (SGR 1806−20, SGR 1900+14, and SGR 0501+4516) and four AXPs (CXO J164710.2−455216, 1RXS J170849.0−400910, 1E 1841−045, and PSR J1622−4950) cannot be detected by *Fermi*-LAT for one-year exposure time, i.e., their SEDs lie below the *Fermi*-LAT sensitivity curve. The SEDs of CXOU J171405.7−381031 lie in the vicinity of the *Fermi*-LAT sensitivity curve. Therefore, the detectability is only marginal. The most notable exceptions are 1E 1547.0−5408, XTE J1810−197, 1E 1048.1−5937, and 4U 0142+61, whose SEDs lie well above the *Fermi*-LAT sensitivity curve. Therefore, they should be detected by *Fermi*-LAT observations.

### 2.2. *Comparison with Fermi-LAT Observations*

The *Fermi*-LAT collaboration has published its observations for all known AXPs and SGRs (Abdo et al. 2010b; five SGRs and eight AXPs). Despite 17 months of *Fermi*-LAT observations, no significant detection is reported. The three SGRs and eight AXPs considered in this paper in Table 1 (except two candidate

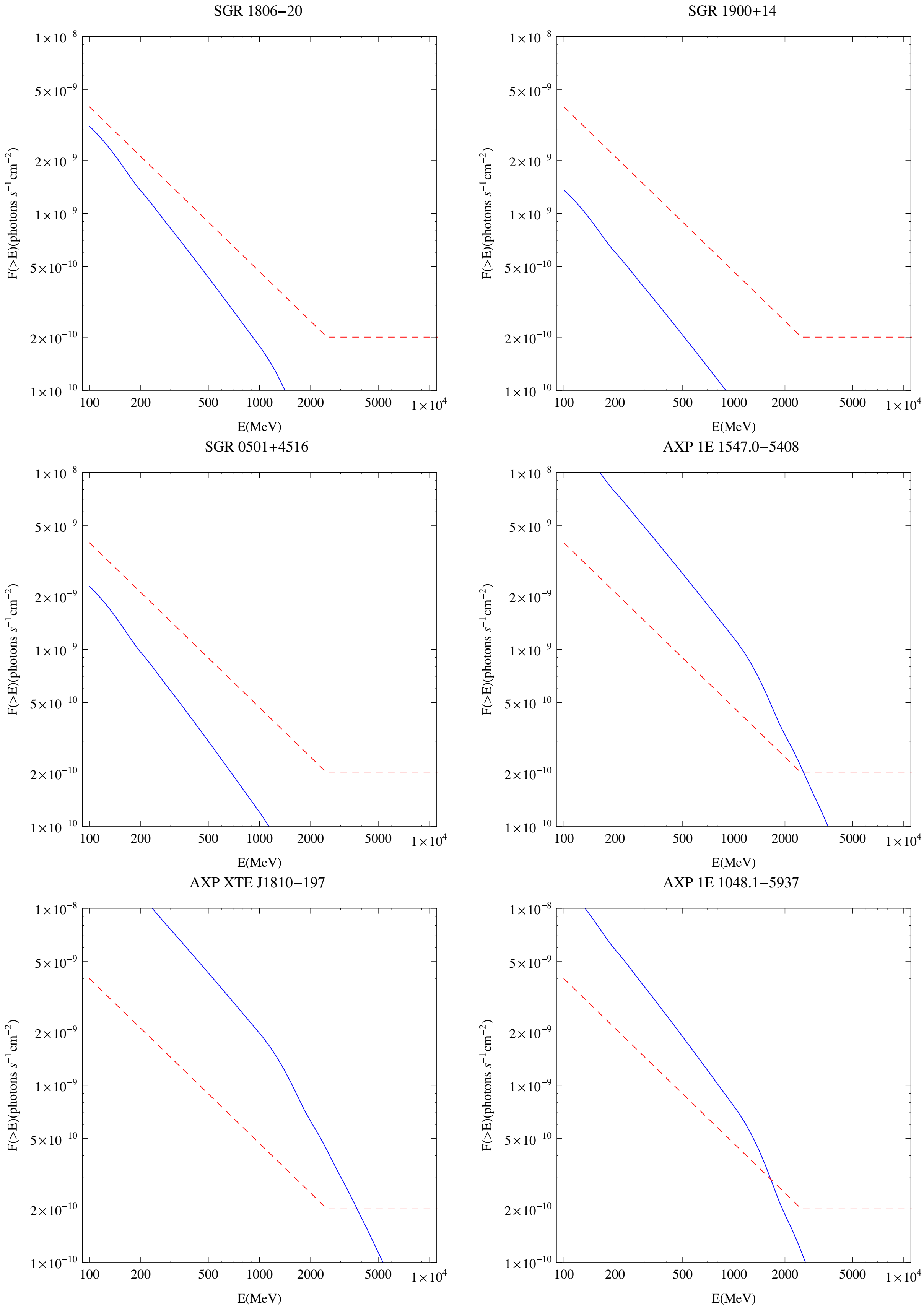


**Figure 1.** Integral spectra vs. *Fermi*-LAT sensitivity curve. The solid line is the theoretical spectra according to the outer gap model (Zhang & Cheng 1997; Cheng & Zhang 2001). The dashed line is the *Fermi*-LAT sensitivity curve for a one-year exposure time (Atwood et al. 2009). Typical calculations for SGR 1806−20, SGR 1900+14, SGR 0501+4516, 1E 1547.0−5408, XTE J1810−197, and 1E 1048.1−5937 are shown.

(A color version of this figure is available in the online journal.)

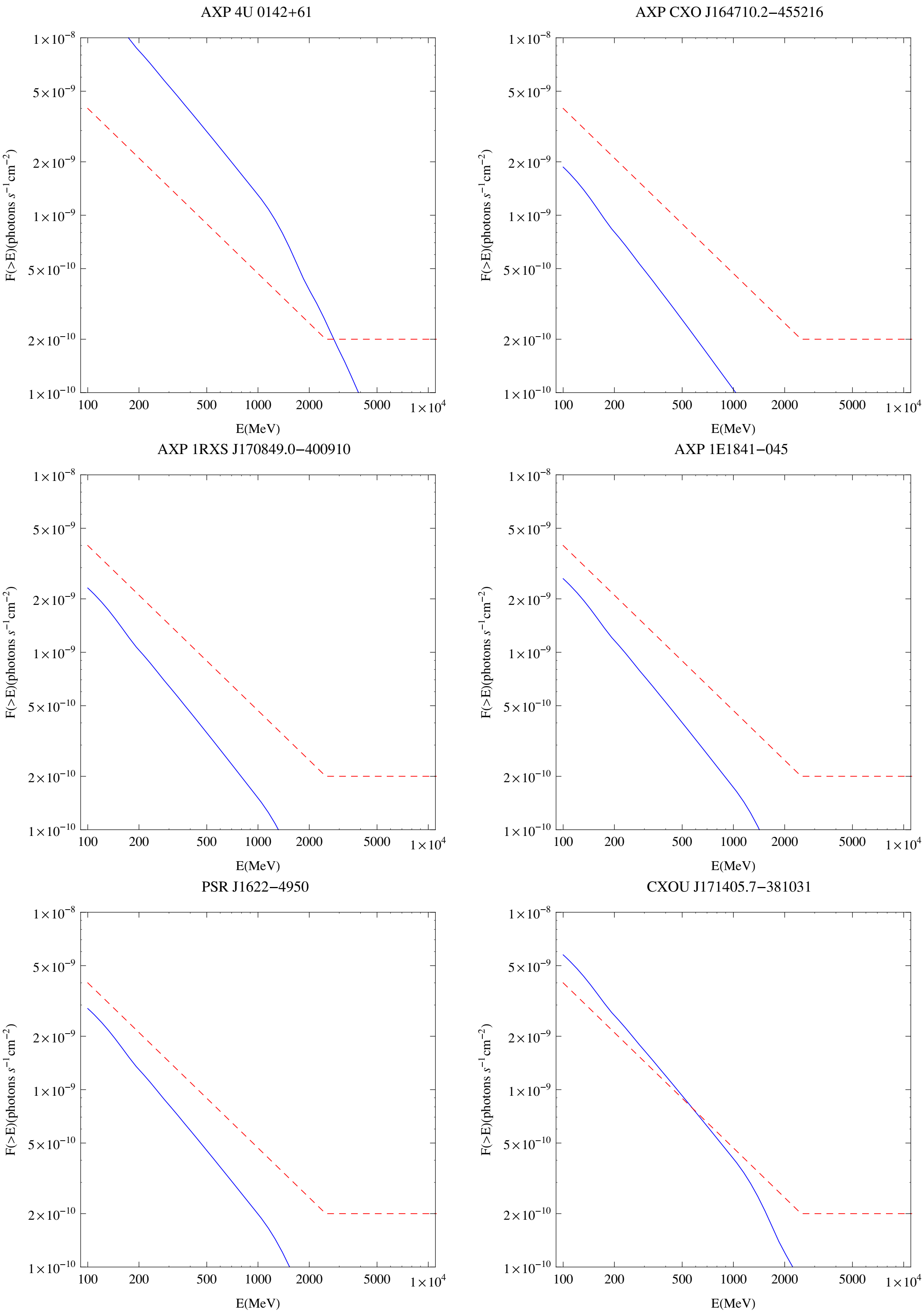


**Figure 2.** Integral spectra vs. *Fermi*-LAT sensitivity curve. Typical calculations for 4U 0142+61, CXO J164710.2−455216, 1RXS J170849.0−400910, 1E 1841−045, PSR J1622−4950, and CXOU J171405.7−381031 are shown.

(A color version of this figure is available in the online journal.)

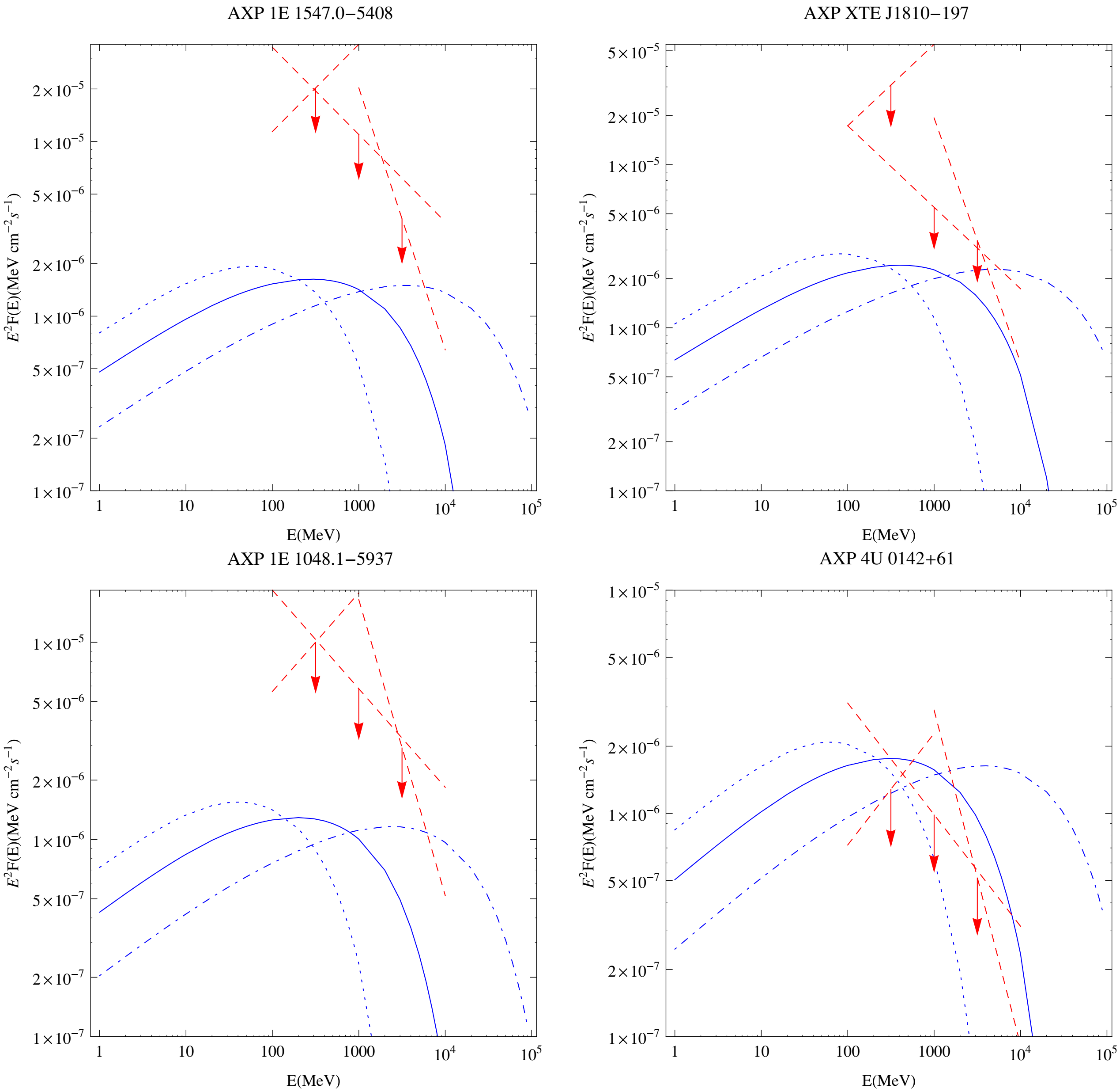


**Figure 3.** Theoretical SEDs vs. *Fermi*-LAT upper limits. The dotted, solid, and dot-dashed lines are theoretical spectra for inclination angles 45°, 60°, and 75°, respectively (Zhang & Cheng 1997; Cheng & Zhang 2001). The dashed lines are *Fermi*-LAT upper limits in energy ranges 0.1–10 GeV, 0.1–1 GeV, and 1–10 GeV (Abdo et al. 2010b). We only show the calculations for 1E 1547.0−5408, XTE J1810−197, 1E 1048.1−5937, and 4U 0142+61, which should have been detected by *Fermi*-LAT for a one-year exposure time.

(A color version of this figure is available in the online journal.)

AXPs), are all observed by *Fermi*-LAT (cf. Table 1 in Abdo et al. 2010b).

1E 2259+586 will not emit high-energy gamma rays according to the outer gap model (Zhang & Cheng 1997). The three SGRs (SGR 1806−20, SGR 1900+14, and SGR 0501+4516) and three AXPs (CXO J164710.2−455216, 1RXS J170849.0−400910, and 1E 1841−045), mainly due to their large distances, cannot be detected by *Fermi*-LAT for a one-year exposure time (17 months exposure time will not make qualitative improvements). Therefore, for these seven sources, current *Fermi*-LAT observations cannot put constraints on theoretical models, i.e., they may be either magnetars or fallback disk systems (see Section 2.4).

Notable exceptions are 1E 1547.0−5408, XTE J1810−197, 1E 1048.1−5937, and 4U 0142+61, which should have been detected by *Fermi*-LAT in 17 months of observations. Therefore, in the case of magnetars, there are conflicts between outer gap predictions and *Fermi*-LAT observations. As noticed by Tong et al. (2010a) for the single case of 4U 0142+61, the non-detection in *Fermi*-LAT observations may propose challenges to the magnetar model. The conflicts between theory and observations are more severe for these four AXPs. We also compare the theoretical SEDs of these four sources with their observational upper limits, shown in Figure 3. The upper limits for 1E 1547.0−5408, XTE J1810−197, and 1E 1048.1−5937 cannot provide strong constraints at present. The upper limits for 4U 0142+61 already lie below the theoretical SEDs for large inclination angles.

### 2.3. The Applicability of the Outer Gap Model to Magnetars

In the magnetar model for AXPs and SGRs, both the bursts and persistent emissions are powered by the magnetic field (Thompson & Duncan 1995, 1996). The self-consistent outer gap model was originally designed for rotation-powered pulsars (Zhang & Cheng 1997). Therefore, the applicability of the outer gap model to magnetars may not seem very convincing at first sight. However, when deducing the star magnetic field from timing observations, the magnetic dipole braking mechanism is employed as in the case of rotation-powered pulsars (e.g., Kouveliotou et al. 1998). The consequence of magnetic dipole braking is that the rotational energy of AXPs and SGRs is carried away by processes similar to that of rotation-powered pulsars. Therefore, there should be some rotation-powered activities in magnetars, and the high-energy gamma-ray emissions are just one of them (Zhang 2003). The high-energy gamma-ray properties of AXPs and SGRs discussed in previous sections are the consequences of their strong surface dipole field.

The magnetosphere of magnetars may be more complicated than that of rotation-powered pulsars, e.g., it may be twisted (Thompson et al. 2002). A twisted magnetosphere contains higher multipoles in addition to a dipole component. Far away in the outer magnetosphere (as in the case of the outer gap model), the higher multipoles will be suppressed dramatically. Thus, the dipole component will dominate in the outer magnetosphere of magnetars. The magnetic field strength there is below the quantum critical value. Therefore, we can apply the outer gap model to magnetars (Cheng & Zhang 2001). Considering the detailed electrodynamics of magnetars, the magnetic field is only quantitatively stronger than the dipole case (Thompson et al. 2002). The corotation charge density now has an extra term in addition to the Goldreich–Julian term $\rho = \rho_{\rm GJ} + \rho_{\rm twist}$ (Thompson et al. 2002). However, the twist term is only present in closed field line regions in the vicinity of the neutron star surface where the magnetic field is strong and highly twisted (Beloborodov & Thompson 2007). In the outer magnetosphere where the magnetic field has been decreased greatly, the Goldreich–Julian term will dominate, and we expect there will also be null charge surfaces as in the case of rotation-powered pulsars. The existence of a null charge surface ensures the existence of outer gaps (Cheng et al. 1986).

Simulations of pair cascades in the strong magnetic field show that the main results are not strongly affected by photon splitting and a magnetar strength field, but are instead only dependent on the acceleration potential (Medin & Lai 2010). The maximum acceleration potential from a rotating dipole is $6.6 \times 10^{12} B_{12} P^{-2}$ V (Cheng 2009). For AXPs and SGRs whose rotation period is about 10 s, if their surface magnetic fields are about $10^{15}$ G, then they may accelerate particles to energy high enough to emit high-energy gamma rays.

In conclusion, the applicability of the outer gap model to magnetars is plausible. AXPs and SGRs are high-energy gamma-ray emitters in the magnetar model because they have strong surface dipole fields.

### 2.4. The Case of Fallback Disk Systems

We now consider the possibility that AXPs and SGRs are fallback disk systems (Alpar 2001; Chatterjee et al. 2000). The accretion flow will quench the magnetospheric activities of the putative neutron star. The radiation due to accretion will be mainly in the soft X-ray and hard X-ray bands (Frank et al. 2003). Recent fallback disk modeling of AXPs and SGRs can explain their soft and hard X-ray spectra uniformly (Trumper et al. 2010). *Fermi*-LAT observations of the most luminous AXP 4U 0142+61 also indicate an energy break at about 1 MeV (Sasmaz Mus & Gogus 2010; Abdo et al. 2010b).

High-energy gamma-ray radiation of AXPs and SGRs in the fallback disk case is considered by Ertan & Cheng (2004) in the disk–star dynamo model (they only calculate the case of AXP 4U 0142+61). In order to generate high-energy gamma rays, the inner disk has to rotate faster than the neutron star. However, this cannot be fulfilled for the debris disk around AXP 4U 0142+61 either as a passive disk (Wang et al. 2006) or as a gaseous accretion disk (Ertan et al. 2007). On the other hand, the outer gap is not supposed to operate in the fallback disk case mainly due to the dense accretion flow. Therefore, AXPs and SGRs are not high-energy gamma-ray emitters if they are fallback disk systems.

## 3. DISCUSSION

Our calculations show that the gap closure mechanism is dominated by the $\gamma - \gamma$ pair production process in the case of magnetars. The seed X-ray photons are provided by surface thermal emission. Observationally there is also a power-law component of soft X-ray photons (Mereghetti 2008). The inclusion of power law soft X-ray photons will enhance the magnetospheric activities of magnetars (Zhang & Cheng 2002). However, physical modeling of the power-law component shows that it is also of thermal origin both in the case of magnetars (Lyutikov & Gavriil 2006; Tong et al. 2010b) and in the case of fallback disk systems (Trumper et al. 2010).

The inclination angle is the main factor determining the spectra shape for different sources; see Figure 3. The larger the inclination angle, the harder the gamma-ray spectra. The modern outer gap model shows that the outer gap may extend below the null charge surface (Hirotani 2006). Tong et al. (2010a) try to take this effect into consideration when calculating the gamma-ray spectra. The corresponding spectra are similar to the case of large inclination angles, e.g., 75°.

During our calculations, the solid angle $\Delta\Omega$ is chosen as unity, which is usually assumed (Cheng & Zhang 2001 and references therein). Outer gap modeling of *Fermi* gamma-ray pulsars also gives an average solid angle of order unity (Wang et al. 2010).

The AXPs and SGRs lie mainly in the Galactic plane. The *Fermi*-LAT threshold sensitivity may be three to five times larger in the Galactic plane than that at higher latitude as in the case of gamma-ray pulsars (Abdo et al. 2010a). This will render the *Fermi*-LAT detectability marginal even for the four most gamma-ray luminous AXPs: 1E 1547.0−5408, XTE J1810−197, 1E 1048.1−5937, and 4U 0142+61. The 17 months exposure quantitatively improves the *Fermi*-LAT sensitivity curve in Figures 1 and 2. Future deeper *Fermi*-LAT observations are required in order to make this issue clear.

In addition to the outer gap model, there are also other high-energy gamma-ray emission mechanisms. For ordinary gamma-ray pulsars, the high-energy gamma-ray radiation should come from the outer magnetosphere (Abdo et al. 2010a). Outer gap (Cheng 2009), slot gap (Harding 2009), annular gap (Qiao et al. 2007), etc., are possible candidates. Calculations in other high-energy emission models are needed.

In this paper, we are mainly concerned with the high-energy gamma-ray properties of AXPs and SGRs. Tong et al.

(2010a) discussed the multiwave properties of 4U 0142+61 as an example. The demerit of the fallback disk model for AXPs and SGRs is that it cannot easily account for the bursts (e.g., Trumper et al. 2010). However, bursts (especially giant flares) in the accretion model are not absolutely impossible (see discussions of Rothschild et al. 2002; Xu et al. 2006; Ertan et al. 2007).

As first pointed out by Tong et al. (2010a), the non-detection in *Fermi* observations of all AXPs and SGRs provides challenges to the magnetar model. AXPs and SGRs are high-energy gamma-ray emitters in the magnetar model because they have strong surface dipole fields. The strong surface dipole field is the consequence of magnetic dipole braking (e.g., Kouveliotou et al. 1998). Since AXPs and SGRs are assumed to be magnetic field powered in the magnetar model, it is possible that they have different braking mechanisms from those of rotation-powered pulsars (e.g., wind braking; Harding et al. 1999). Assuming wind braking for all AXPs and SGRs, the corresponding surface dipole field is in the range of normal radio pulsars (Harding et al. 1999; though they only calculated the case of SGR 1806−20). This may explain the non-detection by *Fermi*-LAT observations of all AXPs and SGRs, at the expense of dropping the commonly referred magnetic dipole braking assumption and the consequent strong surface dipole field. The recently discovered low-magnetic field SGR (SGR 0418+5729 with $B_{\rm dipole} < 7.5 \times 10^{12}$ G; Rea et al. 2010) is consistent with the above analysis. Detailed calculations will be presented in a separate paper.

In the future, if *Fermi*-LAT can detect high-energy gamma-ray emissions from one AXP or SGR, it will be strong evidence for a magnetar dipole field ($B_{\rm dipole} \sim 10^{14}$–$10^{15}$ G) for this source. This will also open another window for measuring the effect of strong magnetic fields, i.e., through the unipolar induction effect. This method is independent of timing measurement, which may be magnetic dipole braking or disk braking. On the other hand, if still no significant detection is reported in *Fermi*-LAT deep observations, it will provide severe challenges to the magnetar model. From Figures 1 and 2, we see that for many AXPs and SGRs, their theoretical spectra are two or three times lower than the *Fermi*-LAT one-year sensitivity curve. Four (nine) years exposure time will make the sensitivity curve two (three) times lower. Therefore, we expect four to nine years exposure time in the future will make this issue clear.

## 4. CONCLUSIONS

In this paper, we calculate the application of self-consistent outer gaps (Zhang & Cheng 1997; Takata et al. 2010) to the case of magnetars and compare the results with *Fermi*-LAT observations of all known AXPs and SGRs (Abdo et al. 2010b). Our calculations show that most AXPs and SGRs will emit high-energy gamma rays and the gap closure mechanism is dominated by the $\gamma - \gamma$ pair production process, if they are really magnetars. For the most gamma-ray luminous AXPs, 1E 1547.0−5408, XTE J1810−197, 1E 1048.1−5937, and 4U 0142+61, their SEDs are above the *Fermi*-LAT sensitivity curve and therefore should have been detected by *Fermi*-LAT. The observational upper limits of 4U 0142+61 are below the theoretical SEDs for large inclination angles. Therefore, in the case of magnetars there is a conflict between the outer gap model (Zhang & Cheng 1997) and *Fermi*-LAT observations.

It is possible that AXPs and SGRs are wind braking, i.e., magnetars without a strong surface dipole field (Harding et al. 1999). It cannot be excluded that AXPs and SGRs are fallback disk systems (Alpar 2001; Chatterjee et al. 2000; Xu et al. 2006). Considering the uncertainties in the outer gap modeling (e.g., the solid angle), future deeper *Fermi*-LAT observations are required. It will help us make clear whether AXPs and SGRs are magnetars or fallback disk systems.

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