

Super flare candidate detected by XMM-Newton

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While superflare surveys on main-sequence stars have been well performed with Kepler satellite in the optical band (e.g. Maehara et al. 2012), there are a few reports in the X-ray band. Hence necessity of statistical study in the X-ray band has been enhanced recently.

We found 23 objects which have the light curves like stellar flares in 2XMMi-DR3 catalog (Watson et al. 2009). Among them, we have identified 22 objects with the stars listed in available optical and infrared catalogs. We made SEDs from the optical and infrared data, and derived temperatures and spectral types (M-type: 18, K-type:3, F-type:1). 9 objects are lower than 3000K. These 9 stars are brown dwarf candidates.

One of the 22 objects is concluded to be a new member of AB Dor moving group (distance: 7 – 77 pc, age: 50 – 120 Myr, Malo et al. 2012), from the coordinate and proper motion. Other two objects have parallaxes in Gaia DR1 (Gaia Collaboration, 2016). We determined distances of them from parallaxes.

Assuming that it is in the main sequence phase, We derived lower limits of other 10 objects (Temperature > 3000 K) from apparent magnitude and the color. The lower limits of distances of other 10 objects are also 10-200 pc, respectively. We calculated X-ray luminosities and lower limits. 6 of 13 objects have luminosities at least 10^{29} ergs s^{-1} , well in the superflare class. We succeed in finding 6 super flare candidates.

◎ No bias flare search

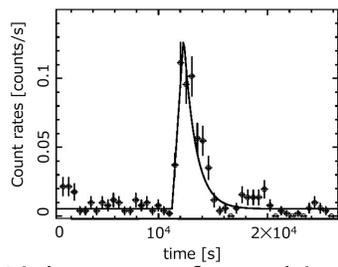
2XMM-DR3 catalog (Watson et al. 2009)

This catalog is the largest catalogue, which contains various types of X-ray sources (262902 unique sources).

We searched the catalog for stars which have the light curves like stellar flares. (Abrupt rise of flux followed by exponential decay)

We detected Unknown 23 objects !

Among them, we have identified 22 objects with the stars listed in available optical and infrared catalogs.



Light curve of our object

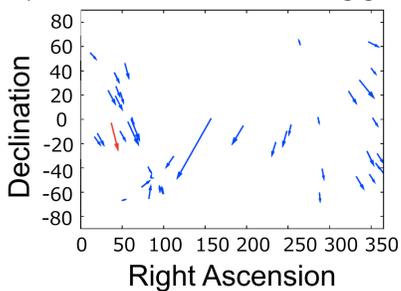
◎ Comparison with near-earth moving group

• Moving group

Members of moving groups have common proper motions. We compared proper motions of our objects with proper motion of near-earth moving group.

➡ One of our objects has proper motion to resemble AB Dor moving group.

Proper motion of AB Dor Moving group



Blue arrow: AB Dor moving group member
 Red arrow: Our subject of research

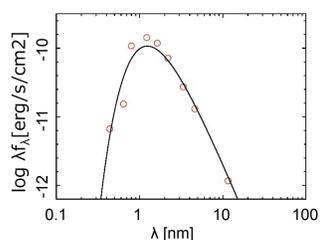
We concluded that one of the 22 objects is a **new member of AB Dor moving group.**

• **AB Dor Moving group**
 Distance: 7-77 [pc]
 Age: 50-120 [Myr]
 (Malo et al. 2012)

AB Dor Moving group is in YSO phase. YSOs originate flares frequently (e.g. Imanishi et al. 2003).

The young age of AB Dor moving group also supports the membership.

◎ Temperature

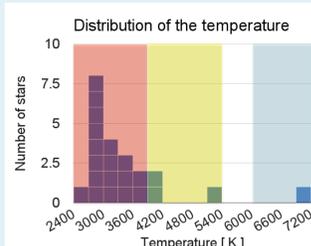


SED (Spectral Energy Distribution)

We made SEDs from the optical catalog (USNO-B1, GSC2.3.2) and infrared catalog (2MASS, WISE).

We determined temperatures from SEDs.

M-type : 18
 K-type : 3
 F-type : 1



• There is the one F-type star. Main-sequence stars with intermediate spectral types are considered intrinsically X-ray inactive.

• 9 objects are cooler than 3000K.

→ Brown dwarf candidate?

There is only one report about a flare occurred on old Brown dwarfs in the X-ray band. **Valuable candidates for them!**

◎ Distance

• Gaia DR1 (Gaia Collaboration, 2016)

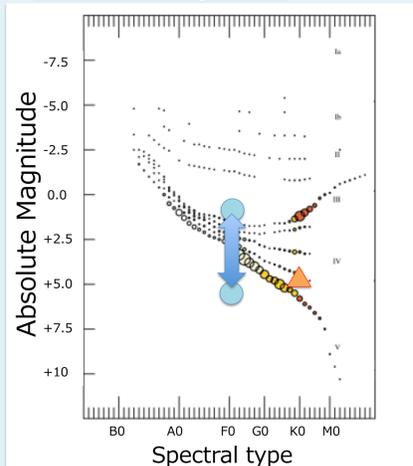
There are data about two objects (F-type: 1, K-type: 1) in Gaia DR1 (Gaia Collaboration, 2016).

We determined distances of 2 objects from parallaxes.

K type :		
parallax [mas]	error	distance (pc)
4.76	0.27	210 (198 – 222)

F type :		
parallax [mas]	error	distance (pc)
1.2	0.88	833 (189 – 1477)

• HR diagram



Sowell et al. 2007

● : F-type ▲ : K-type

F-type:

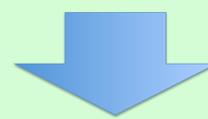
The error of the parallax is too large to determine distance.

K-type:

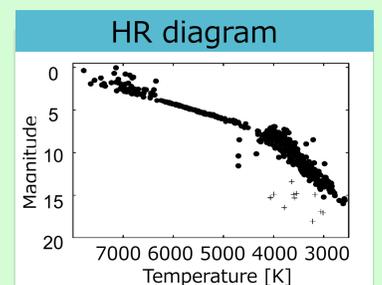
It is not in main-sequence phase.

• Comparison with main-sequence stars

We determined lower limits of 9 objects which have temperature hotter than 3000K. A main sequence is darker than any other phase. Assuming that they are in the main sequence phase, we can derive lower limit of distance from apparent magnitude and the color.

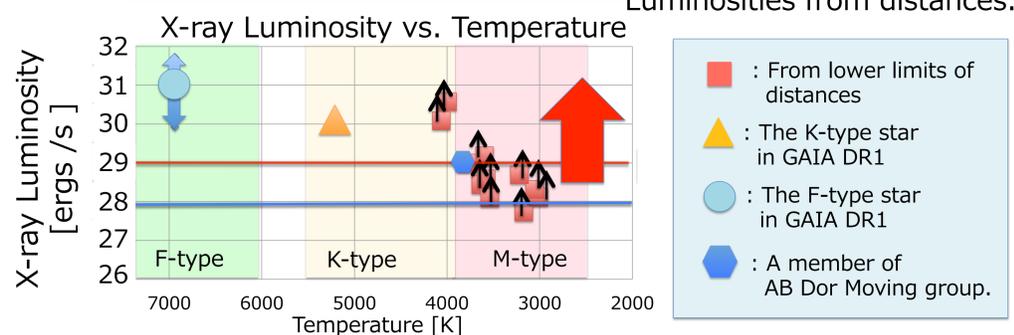


Lower limits of distance



◎ X-ray Luminosity

We calculated X-ray Luminosities from distances.



X-ray luminosity of maximum solar flare is 10^{28} [ergs / s] (blue line)

6 flares are 10 times larger than maximum solar flare (red line)

6 stars are super flare stars!

4 objects of 6 super flare stars (F-type:1, K-type:2, M-type:1)
 It is not contradicted that the 4 objects are main-sequence stars.

Detection of valuable super flare star candidates in main-sequence phase.