Question 1:

Dear Cheap Astronomy – Do other stars have sunspot activity cycles like the Sun does?

Yes, although we say starspots rather than sun spots, when referring to any star other than the Sun. The Sun has an approximately 11 year cycle defined by the number of observable sunspots – which moves from a minimum number to a maximum number over 11 years, and then moves back to a minimum number over another 11 years – hence some people prefer to say it's actually a 22 year cycle. Sunspots arise from the magnetic turbulence that arises from the Sun being a hugely-massive rotating ball of electrically–charged plasma – generating what is sometimes called the solar dynamo. It's thought that the dark spots are points on the surface where magnetic field lines penetrate the surface, reducing heating by convection at that spot and hence making it slightly cooler. Hence, although a sunspot is actually still quite hot and bright, it looks dark relative to the even hotter and brighter parts of the Sun that surround it

So, we do know that most stars spin, indeed we even know some of their rotation speeds. And we know main sequence stars are mostly plasma. So, it's no surprise that these stars have complex magnetic turbulence as well and there are ways to detect them. Early discoveries were based the fact that sunspots on our Sun are associated with particular variation of calcium emissions, and these characteristic patterns were identified in spectroscopic analysis of other nearby stars. Further discoveries drew on interferometry – essentially creating a giant virtual telescope aperture by combining data from different telescopes around Earth. Then it was realised that tracking the transit of exoplanets across the face of a distant star showed signals consistent with the exoplanet occasionally transiting dimmer spots on the star's surface – and it was apparent that dimmer spots were moving in a way that is consistent them being fixed spots on their rotating star.

Anyhow, based on these observations, it has become apparent that not only do other star have star spots but they also have star spot cycles. Much like the Sun, they go from minimal spot to high spot activity and then back again, but the duration of these cycles is very variable. Also, since we are on the edge of detection range with these things, there's a degree of selection bias underlying the data. So pretty much all the star spots we have detected are much bigger than most sunspots we see on the Sun, but the general view is there probably are star spots of a similar to the average size to our sunspots but they are too small for us to detect them.

So, all that is to preface that what we think we know about star spots is based on a data set that may not be fully representative of how most star spots really behave. Nonetheless, based on the ones we can detect, it seems maximum to minimum cycle durations of around 11 years are common though substantially longer durations have been identified, up to 35 years in one case. There's also evidence that other stars flip their magnetic fields at their starspot maximas, which the Sun last did in 2021 when its north pole flipped form positive to negative and its south pole did the opposite.

Star spots are not limited to Sun-like stars either. There's evidence that the closest star to the Sun, Proxima Centauri, which is a red dwarf star has a star spot cycle of less than four years and it's a dramatic cycle where star spots may cover 20% of the star's surface at starspot maxima, while for the Sun it's more like 1 per cent. And is this behavior typical of all red dwarves? Well, that's hard to say given they are quite small stars so it's hard to be sure what's happening on red dwarves that are further away.

So yes it seems that, at least all main sequence stars, do have star spot cycles. It probably best to say that we don't have a big enough data set to start saying definitive things about what kind of cycles are characteristic of stars of a particular size or age or spectral class – and there is a hint that the cycles and star spots of stars in binary and other multiple systems work somewhat differently to solitary stars. Hopefully more observations and data collection while shine more light on this interesting phenomenon. Boom-tish.

Question 2:

Dear Cheap Astronomy – So why are magnetars magnetic?

So, keen listeners will recall that a magnetar is a type of neutron star, all of which do have strong magnetic fields, but magnetars have crazy strong magnetic fields, sufficient to spaghettify sub-atomic particles and polarize a vacuum if you can believe it – not to mention understand it. Keen listeners may also recall there is a growing view that many, if not most, neutron stars go through a magnetar phase at some point in their lives.

But before we even go there, just how the heck do we know these things are magnetic in the first place. This, like a great many things in astronomy is the product of supposition rather than direct measurement. The main data we get from magnetars and neutron stars is the radiation beams that shoot out from each pole, in the form of radio waves for your standard neutron stars and x or gamma rays from your magnetars. When these polar beams that cross our line of sight on Earth, we get a pulse of radiation, kind of like seeing a lighthouse from afar. The pulses tell us how fast these objects are spinning, which for standard neutron stars is fast and for magnetars is crazy fast. And so, since those beams are electromagnetic radiation, a electromagnetic source source is clearly involved and since we know that when you spin something carrying an electric charge you generate a magnetic field. And so QED, neutron stars appear to have magnetic fields and magnetars must then have a crazy powerful magnetic fields.

As patronizing science commentators like to say, so now you're probably wondering where all the charge comes from since neutrons starts are made of neutrons, right? So, it's apparent neutron stars still do retain some charged particles, in addition to all the neutrons that give them their name. The origin of the charged particles isn't altogether clear. The neutron star itself is the remnant core of a star that went supernova – where the core collapse crunched protons and electrons together into a dense ball of neutrons, much smaller than the original core but also much denser. It maybe that a few protons are missed by the big crunch or were later drawn in from surrounding plasma. The tremendous density of a neutron star means gravity at its surface is also pretty tremendous, so anything that approaches its surface will be trapped and held by it.

Either way, despite all the neutrons there clearly are still some charged particles, probably more in the stars' outer crust, so when the star spins they generate a very powerful magnetic field. It's thought that the field drives the motion of charged particles channeling them towards the poles so they are driven together there, creating heat as well as radiating light. At least that's roughly how it works, maybe – we mostly guess at the possible mechanisms based on the data we get, rather than any direct observations of those mechanisms themselves. Another bit of data, which supports this whole hypothetical framework is that neutron star's rapid spin rates are slowing – not by much, but in a measurable and steady way. Given what we just said about conservation of momentum and that the thing is spinning in a vacuum, this is hard to explain why that would happen unless you invoke a magnetic field, which is essentially braking the stars spin through drag generated by all charged particle interactions – where angular momentum energy is being converted into the heating and the radiation beams.

So, taking all that thinking back to the context of magnetars. Rather than beaming out radio waves, they are beaming out gamma and x rays. So that implies a much more powerful magnetic field is at work, which create more heat and higher intensity radiation beams. And while magnetars spin really fast, their spin down rate is also fast, where the average life of a magnetar is only around 10,000 years. So, that also supports the thinking that a much more powerful magnetic field is at work, since there's more braking going on.