The heat capacity of a star was estimated using the virial theorem as

$$C_V = -\frac{3}{2}Nk$$  \hspace{1cm} (1)

where $N$ is the number of particles (typically dissociated protons and electrons) in the star. A negative heat capacity is typical of gravitationally bound systems.

We can use this to work out the entropy from the formula

$$S = \int \frac{C_V(T)}{T}dT$$  \hspace{1cm} (2)

$$= -\frac{3}{2}Nk\ln T + f(N,V)$$  \hspace{1cm} (3)

where $f$ is some function that depends on $N$ and the volume $V$, but not on $T$.

The total energy of a gravitationally bound system is negative and, from the virial theorem, we have

$$U = -K = -\frac{3}{2}NkT$$  \hspace{1cm} (4)

where $K$ is the kinetic energy and the formula is obtained from the equipartition theorem. Thus the entropy can be written in terms of the energy as

$$S = -\frac{3}{2}Nk\ln \left| \frac{2U}{3Nk} \right| + f(N,V)$$  \hspace{1cm} (5)

We can incorporate everything inside the logarithm except for $U$ into the function $f$ (call the new function $g$, say), so that

$$S = -\frac{3}{2}Nk\ln |U| + g(N,V)$$  \hspace{1cm} (6)

The general shape of this curve is like this (units on the axes are arbitrary as I’m just trying to show the shape of the graph):
The graph is concave upwards, which is typical of systems with negative heat capacity as we discussed earlier. For sufficiently low (large negative) values of $U$, the graph would go negative, but I would guess that the temperature at that point would be higher than anything found in real stars so that would never happen. Note that as $U \to 0$, $S$ effectively becomes infinite. At $U = 0$, however, the system becomes gravitationally unbound, so the particles would presumably then be able to wander over the entire universe, giving them an infinite number of possible states.