<u>Estimating the distance of a type Ia Supernova.</u> Dave Eagle FRAS.

Type Ia supernovae are extremely useful in measuring the distance of remote galaxies. It is known that type Ia supernovae always reach the same brilliance at their peak. Like Cepheid variables they can be used as “standard candles” to determine distances. Type Ia supernova are extremely brilliant, often outshining their parent galaxy, so unlike Cepheid variables they can be observed across tens of millions of light years. So the distances to very distant galaxies can be determined using them.

So let’s work out how to determine the distance to a distant galaxy if we know the brightness of a type Ia supernova.

A typical type Ia supernova has an absolute magnitude of -19.3.
As this is fairly well set in stone, if we observe a supernova in a distant galaxy and measure the actual magnitude that we observe, then the difference in apparent brightness gives us a reasonably good measure of the galaxies distance.

The formula used is:

$M = 5 + m - 5 \log d$.

Where M = Absolute magnitude (Magnitude -19.3).
m = Apparent magnitude (Brightness as observed from Earth).
d = Distance in Parsecs. (1 Parsec = 3.26 light years).

A Type Ia supernova (SN 2011fe) was seen in M101 in 2011. The brightest apparent magnitude it attained was +10. This was easily viewed by amateur astronomers for many weeks, even bright enough to be seen in binoculars.

Figure 1. Supernova 2011fe in M101 in 2011. Dave Eagle.

We now have all the information we need to rewrite the equation to start to calculate the distance to M101.

$19.3 = 5 + 10 – 5 \log d$

Simplified: $19.3 = 15 – 5 \log d$

The only unknown is now the distance, so the equation can be re-arranged thus:

$5 \log d = 15 + 19.3$

$5 \log d = 34.3$

This is then re-arranged to give:

$\log d = \frac{34.3}{5}$: $\log d = 6.86$

The anti-log of 6.86 from a scientific calculator gives us 7,244,359 parsecs

As there are 3.26 light years in a single parsec, our final calculation gives us:
7,244,359 x 3.26 = 23, 616,612

So our final calculation gives us a distance to M101 of 23.6 million light years.

The currently accepted distance of M101, determined by the latest Hubble Cepheid variable measurements is around 22 million light years. So our rough calculation is really not too far out. So it's not bad from a fairly casual observation made at the telescope.

The real trick in using type Ia supernova to determine their distance is to catch them long before they reach maximum brightness, so that we can be sure that we are measuring them at their maximum stage, and we are sure that the supernova is of Type Ia.