Beyond the range of the Cepheids

The Cepheid variables were ideal stars, in their way, for extending the distance range beyond our own Galaxy. As you know, Cepheids are intrinsically bright (that is, luminous), ranging from about three hundred and fifty to sixty-thousand (sic) times the absolute luminosity of the Sun; they are seen far out into space. However, they have their limitations. Beyond 5 Mpc Cepheids become too faint to be used as "galactic yardsticks," with the result that, of the billions of galaxies in the universe, only thirty or so are close enough to have their distances determined in this way.

However, the Cepheids are not the brightest stars known. In our own Galaxy, the brightest, hottest, blue stars — sometimes called blue supergiants — have an absolute luminosity about 5×10^5 times that of the Sun. Hubble suggested that perhaps these could be used to stretch the distance scale further. He argued that, statistically speaking, it was not unreasonable to suppose that the brightest blue stars in one galaxy have the same absolute luminosity as the brightest blue stars in any other galaxy; in other words there is an upper limit to the absolute luminosity that a star can have.

Fortunately, Hubble could do more than just speculate — he could test his idea on those galaxies for which he had already obtained reasonable distance estimates by the Cepheid method. When he did, he found that the apparent brightnesses of the brightest blue stars in each of the galaxies in his sample were (within a factor of two or so) inversely proportional to the square of the distances of these galaxies — exactly as would be expected if the absolute luminosities were constant from galaxy to galaxy. [We now believe that there are good theoretical reasons for accepting this assumption. The brightest stars are thought to be the most massive stars, and the upper limit to the mass that a star can acquire during its formation is probably about the same in all galaxies] Emboldened by this confirmation of his idea, he proceeded to measure the apparent brightnesses of the brightest stars in galaxies beyond the range of the Cepheids, and so compute their distance. In this way he managed to push the distance limit out to about 10 to 15 Mpc. Several other statistical techniques have been devised to extend the distance range beyond that provided by the Cepheids. For example;

(i) if the average size of luminous-gas regions is assumed to be the same in all galaxies, then, galactic distances can be found by measuring the angular size of these regions;

(ii) if supernovae are assumed to reach the same peak intrinsic (absolute) brightness (better still, luminosity) on average, no matter where they are located, then, galactic distances can be deduced from a comparison of apparent peak brightnesses of these supernovae;

(iii) if the star clusters in different galaxies are assumed to have the same average intrinsic luminosities, then, galactic distances can be found by comparing the average apparent brightnesses of the clusters.