Twinkle-Twinkle…

This phrase, by George Gamow in 1964, came about as a result of the discovery of the first Quasi-Stellar Radio Source, or Quasar, Catalogued as 3C273 in the Virgo Constellation and it is the optically brightest in the sky and one of the closest to Earth at about 2.5 Billion Light-Years distance. It was first discovered by Cyril Hazard and Maarten Schmidt. It has an optical counterpart, but is immensely strong in its radio emissions, of the order of 46.4 Jansky (Jy) at 1,400 MHz, where Jansky is a measure of the spectral flux density and 1 Jansky is the equivalent to 10^{-26} W Hz^{-1} m^{-2}. Incidentally, the red-shift of 3C273 shows that it is receding away from us at 47,000 km s^{-1}, but there are other Quasars that are receding by orders of magnitude more than this! Quasars were present more in the ancient Universe and are typically Active Galactic Nuclei resulting from Super-Massive Black Holes at galactic centres. This play on the traditional nursery-rhyme words shown here may have been a little bit of a joke-around at the time, but the "twinkling" part has become a powerful tool for radio astronomy – scintillation.

So, let's think: why to stars twinkle, and not planets – can anyone tell me?

Stars twinkle in optical light because their angular diameters are very small, typically of the order of milliarcseconds or less. Therefore, they suffer interference as the light passes through the Earth's turbulent atmosphere. The reason planets do not do this is because they subtend a very large angular diameter by comparison, several arcseconds or more – this makes them lose their twinkle in optical light.

So, what about astronomical radio sources – why do they twinkle?

Well, the same principle can be applied. As the radio waves pass through the various ionised plasmas of the Interstellar Medium, the Interplanetary Medium, and the Earth's Ionosphere, travelling vast distances through space from the very-distant radio source to the observer on the Earth, cells of turbulence of various scale-sizes and velocities allow for several forms of radio "twinkling", or scintillation, to arise. Therefore, the same principle applies: if a Quasar is small enough, then it will scintillate, and if it is not, then it won't. The problem is that Quasar's really need to be really small to scintillate – of the order of milliarcseconds for interplanetary scintillation (and ionospheric scintillation too) – but even smaller if you were to look at the Interstellar Medium through Interstellar Scintillation; here you would want your source sizes to be of the order of microarcseconds! By comparison, this is about the size Neil Armstrong's big toe would subtend when he was on the moon as viewed from the Earth. The turbulence and small-scale density variations in the solar wind cause rapid variations in the apparent source intensity of the radio waves coming from a Quasar causing interference as they pass through the turbulent Interplanetary Medium and hence give rise to Interplanetary Scintillation, of IPS for short.