Neutrinos in an Expanding Universe

Dr. Richard Wigmans – TTU

The observable Universe contains approximately 10^{87} neutrinos, several billion neutrinos for every baryon. During the first second after the Big Bang (the Leptonic Era), these neutrinos were in thermal equilibrium with the other constituents of the Universe. At the end of this Era, they decoupled. For all practical purposes, they no longer interacted with other particles from that point onwards.

In this talk, we follow these relic neutrinos throughout the history of the Universe. We will see how their properties changed as the Universe went through an expansion by 10 orders of magnitude. At the present time, they are extremely non-relativistic, with typical velocities of a few hundred km/s. This means that they have become susceptible to gravitational forces and that gravitation locally may have changed their spectra.

I will show that this, under certain assumptions, may have led to a phenomenon that would explain two of today's great mysteries: The large-scale structure of the Universe and the increasing rate at which it expands. This explanation does not involve new forces or unknown forms of energy, but is based on a well-known quantum mechanical effect: the Pauli Exclusion Principle.

The proposed mechanism makes it possible to calculate the present value of the Hubble constant from first principles and sets a lower limit on the neutrino mass. For the latter, we find $m_\nu > 0.25$ eV/c^2 (95% c.l.).