Issues and Prospects regarding THE DIRECT DETECTION OF DARK MATTER

J. D. Vergados
Theoretical Physics Division, University of Ioannina, Ioannina, Gr 451 10, Greece,
(Dated: November 2, 2010)

The recent WMAP data have confirmed the previously existing evidence for the presence of dark matter in galactic halos. Thus we know that exotic dark matter together with the vacuum energy (cosmological constant) dominate in the flat Universe. Modern particle theories provide viable cold dark matter candidates with masses in the GeV-TeV region. All such candidates are called WIMPs (Weakly Interacting Massive Particles).
The nature of dark matter, however, can only be unraveled by its direct detection in the laboratory. In the standard direct dark matter searches one measures the energy of the recoiling nucleus. In such experiments, unfortunately, the interesting signal cannot be easily distinguished from the background. In spite of this with heroic efforts the current experiments have already managed to reach for the **coherent process** the impressive limits of nucleon cross sections of $\approx 10^{-43}\mathbf{cm}^2 = 10^{-7}\mathbf{pb}$.
To minimize the background problems, one should exploit some characteristic signatures of the reaction, such as the **modulation effect** and, in directional experiments, the **correlation of the event rates with the sun's motion**. We will show that in the standard experiments the modulation is small, less than two per cent, and the location of the maximum depends on the unknown WIMP mass.
In directional experiments, in addition to the forward-backward asymmetry due to the sun's motion, one expects a larger modulation, which depends on the direction of observation.
Since the direction of observation is fixed with respect the earth, while the Earth is rotating around its axis, in a directional experiment the angle between the direction of observation and the Sun's direction of motion will change during the day. So, since the event rates sensitively depend on this angle, the observed signal in **directional experiments** will exhibit very interesting and characteristic **periodic diurnal variation**.
The above experiments are expected to extract the coherent nucleon cross section, if it is sizable. Particle theories, however, also predict cross sections induced by the axial current, which may even dominate in odd mass targets. For such targets one cannot separate the coherent mode from the spin induced cross section. We will show that given a judicious choice of odd targets one may be able to separate the coherent from the proton and neutron spin induced cross sections, and extract all of them from the experiments.

PACS numbers: 95.35.+d, 12.60.Jv