The Methods for Direct Detection of WIMP with Mass ≤ 0.5 GeV

B. M. Ovchinnikov*, I. I. Tkachev, V. V. Parusov

Institute for Nuclear Research, Russian Academy of Sciences, Moscow, Russia

Abstract
The chamber for direct detection of WIMP with mass ≤ 0.5 Gev was developed. The chamber is filled with gas mixture Ne+10% Hydrogen +0,15ppm Tetramethylgermanium (TMG). For events detections used GEM+pin-anodes, which provide the energy threshold about eV. The electron background is suppressed owing to photosensitive addition TMG. It is proposed also for direct detection of WIMP the liquid argon chamber with Hydrogen dissolved in liquid argon at a concentration 100ppm+0,015ppm TMG.

Keywords
Search the Low Mass WIMP, Metallic GEM+Pin-Anodes, the Energy Threshold About eV

1. Introduction
The measurement of cross section of WIMP scattering on proton is necessary to clear up the dark matter nature [1, 2].

Astronomical observation give strong avidense for existence of non-luminous and nonbarionic matter, presumably composed of a new tipe of elementary particles. The detectors with pure NaI [3], Xe or Ar allow to search the WIMP with large mass (of dozens or hundreds GeV), because the energy of nuclear recoils in these detectors from low mass WIMP are low. The experiments with nobles gases are shown in Table1. To account for yearly modulation effect in DAMA-LIBRA experiment [3] J.Va’vra [4] have supposed that this effect is explained by low mass WIMP scattering on protons in H$_2$O molecules which contamination about 1ppm in NaI crystals.

2. Spherical Proportional Detector
The spherical proportional detector was developed for search the low mass WIMP [5].

This detector was filled with H$_2$ or Ne and has the energy threshold about 100 eV.

3. Double-Phase Argon Chamber
The double-phase argon chamber with mass up to 10$^4$ tons was proposed for WIMP detection in our work [6]. For electron background suppression was proposed the photosensitive addition Ge (CH$_3$)$_4$[7]. For detecting events in gas-phase was developed the system metallic GEM[8]+ pin –anode with 10%H$_2$ addition and $K_{\text{amp}}=5\cdot10^7$ [9]. The concentration H$_2$ in liquid Ar is equal about 100 ppm, this allows to detect the low mass WIMP (≤0.5GeV) also because the concentration H$_2$ is 100 time more then in [3].

By comparing the work[5] ,where the energy threshold is equal ~100 eV ,with amplification factor of detecting system~10$^4$,we can to estimate the threshold of our experiment as 100 eV・10$^4$/5・10$^7$~1eV.
4. The Chamber with Ne+10%H₂(0-1bar) Filling

On Fig. 1 is shown the system GEM+ pin-anode, which is used for events detecting in this chamber and in double-phase argon chamber. The front of signal in this system is equal ≤3 µsec. The detecting of front allows to measure the event dimension in z-direction for electron background suppression[5].

Figure 1. GEM+pin-anode.

For purification of gases are used the methods with Ni/SiO₂ adsorbents[10]. The addition in chamber of Ge (CH₃)₄ allows to suppress the electron background (gamma-background, Ar³⁹ and tritium decays).

On Fig. 2 the dependence of $K_{\text{ampl.}}$ on potential difference between the pin-anode and GEM is shown. The use in chamber of spectrometric amplifier allows to obtain the energy threshold about eV. This energy threshold allows to search the WIMP with mass ≤0.5 GeV/c² (see table2). Double-phase Ar chamber or the chamber with Ne+10%H₂ filling are placed in low background laboratory in low background shielding for search the yearly or daily modulation effects.

The double-phase argon chamber and chamber with Ne-filling allow to search the axions, emitted from the sun.

The chamber with Ne+10%H₂ filling is shown on Fig.3.

Figure 2. The dependence of $K_{\text{ampl.}}$ on potential difference between the pin-anode and GEM, $K_{\text{ampl.}}= Q_{\text{ampl.}}/Q_{\text{ioniz.}}$, where $Q_{\text{ampl.}}$ –the charge detected, $Q_{\text{ioniz.}}$ –the ionization charge.

Figure 3. The chamber with Ne+10%H₂ filling.

The chamber consists of titanium body 1, of detecting system (metallic GEM 4 +36 pin-anodes 5), of wire cathode 2, wound with 0.1 mm in diameter of beryllium bronze wires. The positive voltage on cathode with respect to chamber body suppress the background from cathode. The electrodes 3, produced from pure copper, forms in volume of the chamber the electric field.

For improvement sensitivity of chamber to low mass WIMP it is necessary to add in Ne-filling of the chamber the 1ppm TMAE (tetrakis dimethylamino ethylene) [7], which has the low ionization potential 5.36eV. When the recoil proton come into collision with TMAE molecule, the molecule TMAE is ionized and the signal from low mass WIMP is increased.
The method of H₂ addition in liquid Ar and method of event detecting, proposed in this paper allows to search the low mass WIMP in all experiments with Ar chamber.

5. Conclusion

The method of H₂ addition in liquid Ar and method of event detecting, proposed in this paper allows to search the low mass WIMP in all experiments with Ar chamber.

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