High Sensitivity NaI(Tl) Detector for Dark Matter Search

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1 Dark Matter Candidates and Search for Dark Matters

In the last decade, the dark matter candidates has been extensively studied by many groups in the world. Since a scintillation detector has many great advantages to search for dark matter candidates, many groups has been applied scintillation detectors [1, 2, 3, 4]. The WIMPs (Weakly Interacting Massive Particles) is one of the most promising candidates for cold dark matter (CDM) [5]. Since a NaI(Tl) scintillator has the large cross section for WIMPs, the large output of light and large acceptance, a NaI(Tl) scintillator is more advantageous than the other detectors. The Feinman diagram of WIMPs (χ)-nucleus scattering is shown in Fig.1.

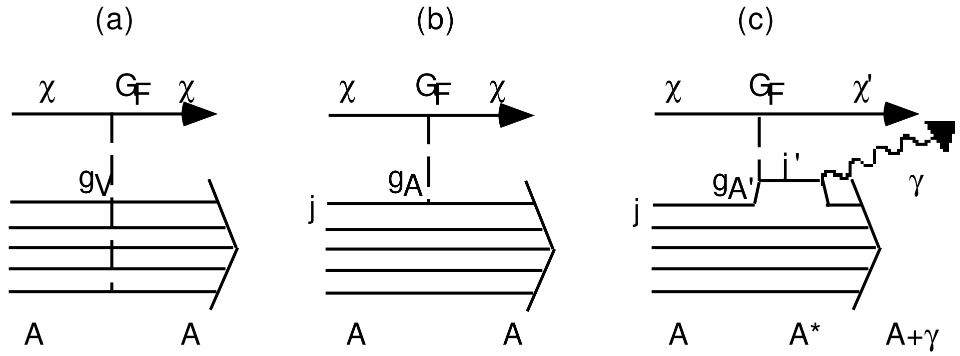

Figure 1: Interaction of WIMPs (χ) from a nucleus A. (a) Elastic scattering of spin-independent WIMPs (SI). (b) Elastic scattering of spin-dependent WIMPs (SD). (c) Inelastic scattering of spin-dependent WIMPs, exciting one valence nucleon from the j to the j' orbit (IE).

Recently, DAMA group has reported the possibility of a significant annual modulation for spin-independent WIMPs candidates [2, 6]. They uses the highly radio-pure NaI(Tl) with the mass of 100kg at Gran Sasso Underground laboratory. Their measurement of 19511kg$\cdot$day favors the hypothesis of the presence of a modulation with the mass $m_\chi = (59^{+17}_{-14})$GeV and the WIMPs-proton cross section $\xi\sigma_p = (7.0^{+0.4}_{-1.2}) \times 10^{-6}$pb at 99.6% C.L., where $\xi \equiv \rho_\chi/\rho_0$ [6].

2 High sensitivity NaI(Tl) scintillator for dark matter search

The high sensitivity detector will be constructed in order to search neutralinos whose cross section in the region of $\sigma_p \simeq 10^{-6}$pb. A high purity NaI(Tl) scintillator is manufactured

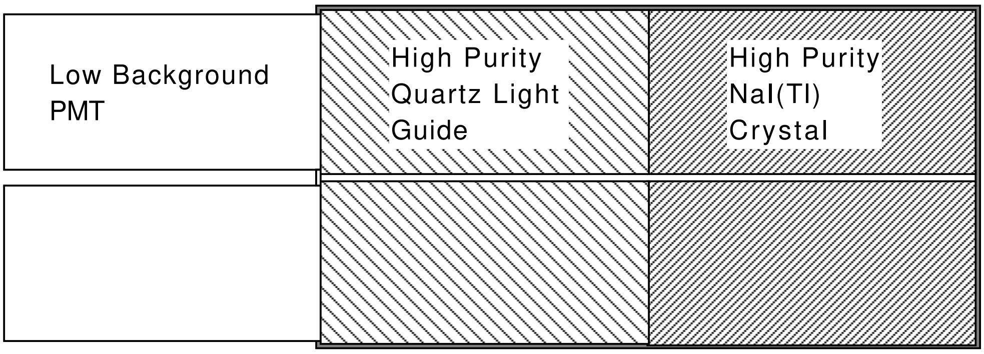

Figure 2: Schematic view of the NaI(Tl) scintillator.

taking care of the density of U, Th and K contaminants. Moreover, the selectivity of the detector system is increased by constructing a segmented (multi-) detector system. All signals from the segmented detector modules are recorded on a disk for identifying properties of the events and their origins in the off-line analysis. The schematic view of the new NaI(Tl) detector is shown in Fig.2.

The elastic scattering of neutron cannot be discriminated from the true event of WIMPs, thus the effect of neutron should be monitored. The neutron monitor will be installed in the new detector system. The neutrons in the laboratory are thermalised by surrounding paraffin bricks and absorbed by cadmium sheets.

The new detector will be constructed in the summer in 1999. The measurement of annual modulation of WIMPs energy spectrum will be continued for at least one year The sensitivity of the new detector for dark matters will be improved at least two orders of magnitude, thus the sensitivity for WIMPs will reach the cross section region below $\sigma_p \simeq 10^{-6}$pb.

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