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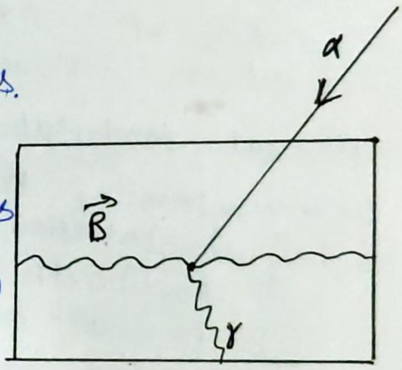
Q: Search for Dark Matter Particles.

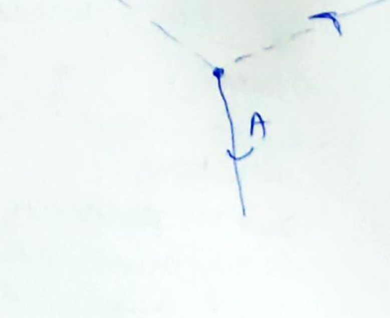
Ans:
* Dark Matter and the mass of neutrino
In 1980, the experimental claims on the existence of the mass of electron neutrino about 30eV lead to immediate cosmological consequence of the neutrino dominated Universe. In which massive neutrinos play the role of DM.

* Direct searches for Dark Matter.
The coherent intensification of the interaction of relict massive neutrinos with grains of matter with a size on the order of the neutrino wavelength suggests that it might be possible to detect a galactic neutrino sea by virtue of the mechanical pressure which it exerts in the direction opposite that in which the Solar system is moving in the galaxy.

* Direct searches for Cosmic axions.
Searches for cosmic axions use the effect of light, coming through the walls, - axion conversion in photons in radio-frequency cavity.
Axion emission is severely constrained by the observational data on the stellar evolution. Effects of archials can hardly let axions to be the dominant form of DM



* WIMP-nucleus interaction
Dark Matter can consist of Weakly Interacting Massive Particles (WIMPs). Such particles can be searched by effects of WIMP-nucleus interactions.



* Direct Search for DM (WIMPs)

AX- interaction in non-relativistic limit

① Scalar (takes place for Dirac fermions)

$$\sigma_{AX} \propto \left[g_p \frac{Z}{A} + g_n \left(1 - \frac{Z}{A}\right)^2 \right]^2 A^2 \mu^2$$

weakly depends on target nucleus because
Z/A ≈ const

② spin-spin (takes place for Majorana fermions)

$$\sigma_{AX} \propto \left[g_p \langle S_p \rangle_A + g_n \langle S_n \rangle_A \right]^2 \mu^2$$

Strongly depends on target nucleus,
because ⟨$S_{p,n}$⟩ depends on nucleus structure

⇒ Interpretation of experimental results in terms of spin-spin AX-interaction is more dependent on detector material.

* Annual Modulation of WIMP effects

Minimization of background:

① Installation deeply underground
② Radioactively pure materials
③ Annual modulation.

⇒ DM does not participate in rotation around GC.

* DAMA/NaI and DAMA/LIBRA

The data favor the presence of a modulated behaviour with all the proper features for DM particles in the galactic halo at about 9.2σ C.L.

* Direct Search for SIMPs

Rocket experiment XQC:

If DM consists of Strongly Interacting Massive Particles (SIMPs), they could be braked down by ordinary matter and become insensitive for underground detectors.

Such particles could be searched for in X-cosmic ray experiment XQC, aimed at observation of X-rays and realized during a rocket flight.

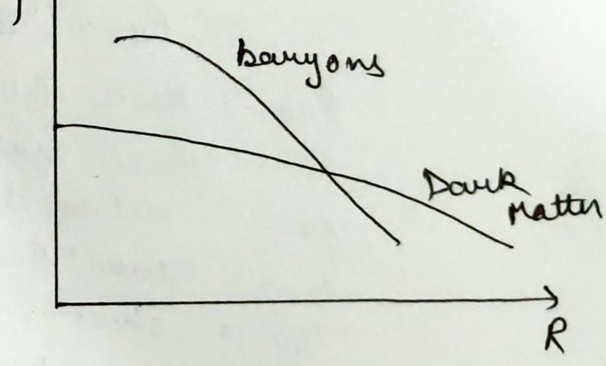
XQC experiment

- data taking time ~ 100s
- material of detector ~ Si + HgTe
- energy deposit range of sensitivity ~ 25-1000 eV
- the range being good for extraction of SIMP-nucleus interaction event from background ~ 25-60 eV.

* Indirect searches for Dark Matter

Condensation of DM in Galaxy

- Motion of collisionless gas in nonstationary field of baryonic matter, contracting owing to dissipation of baryonic matter, contracting owing to dissipation processes, provides effective dissipation and contraction of this gas.
- In result collisionless DM condenses in Galaxy, but it is distributed more steeply, than baryonic matter.
- It qualitatively explains the difference in distribution of baryons and DM.
- Due to condensation effects of annihilation in Galaxy can be significant even for subdominant DM components (e.g. 4th neutrino).



Ques 2. Primordial Black Holes

Ans :- * Existence of superheavy metastable particles in the very early Universe leads to stages of their dominance, at which growth of their density fluctuations leads to formation of their gravitationally bound systems, including black holes.

* Black holes, formed at this stage, must retain in the Universe after decay of particles, which have formed them, and at the mass $M > 10^{15} g$ must be present in the modern Universe as a specific form of DM.

* Black holes of smaller mass evaporate by mechanism of Hawking.

* Effects of this evaporation are similar to effects of decay of unstable particles with one important difference — the products of evaporation are all the existing particles with mass, smaller than the temperature of evaporation.

* The characteristic of the black hole are its mass M, charge Q, and angular momentum L.

A Black Hole is a solution of Einstein's eqn

$$R_{\mu\nu} - (1/2) g_{\mu\nu} R = 8\pi G T_{\mu\nu} - g_{\mu\nu} \Lambda$$

$R_{\mu\nu}$ → Ricci curvature tensor

R → Ricci scalar

$g_{\mu\nu}$ → metric tensor

G → Gravitational constant

$T_{\mu\nu}$ → stress-energy tensor

Λ → Cosmological constant.

formation of PBH:

* PBH as a manifestation of the dust-like stages in the early Universe.

On the dust-like stage gravitational instability evolves within the cosmological horizon. At this stage the growth of small perturbations can cause to the formation of inhomogeneities which can collapse and form PBHs.

* Direct formation of PBH.

The idea of direct formation of PBHs due to the fact that the inhomogeneities are formed in the early Universe, and the growth of their fluctuation entail the formation of sufficiently homogeneous and isotropic configurations

* formation of PBHs in the first-order phase transitions

In the process of the first-order phase transitions collisions of bubble walls can concentrate the kinetic energy of the walls within its gravitational radius, thereby forming a PBH.

* formation of PBH in the collapse of the closed walls.