1. Neutrinoless Double Beta Decay

- Neutrinoless double beta decay
  - Lifetime and neutrino mass
    \[ T_{\beta\beta}^{\text{exp}} \times (10^{22} - 10^{24}) \] #1 \[ \approx T_{\beta\beta} (E_{\beta\beta}, M_\nu) \times c^2 \] #2
  - Energy spectrum and lifetime measurement
    - monochromatic energy = Q-value
    - \( T_{\beta\beta} = \lambda M_{\text{BB}} \) : abundance
    - mass
    - time \( \Delta E \) : energy res.
    - \( B_G \) : BG rate

**Requirement:** Low background rate, Large target mass and High energy resolution

- Double beta decay candidates
  - above \( ^{208}\text{TI} \gamma \text{line (2.614MeV)} \): \( ^{46}\text{Ca}, ^{150}\text{Nd}, ^{92}\text{Zr}, ^{108}\text{Mo}, ^{112}\text{Se} \)
  - large abundance : \( ^{108}\text{Mo}, ^{112}\text{Se}, ^{150}\text{Nd}, ^{92}\text{Zr} \)
  - solved in liquid scintillator formed as metal complex

Zirconium (\( ^{92}\text{Zr} \)) is possible candidate

- Experimental limits for neutrino
  - Detector design for Zr loaded liquid scintillator

Same as EGAD

Assuming 10w.t.% solubility

- high energy resolution : \( 4\%@2.5\text{MeV} = 100\text{keV} \)
- low background rate : \( 0.01\text{count kg}^{-1} \text{y}^{-1} \)
- large target mass : ~ ton scale

Goal: \( <m_s> \sim 10\text{MeV} \)

2. Zirconium Complex

- Zirconium (IV) acetylacetonate
  - good solubility (over 10w.t.% in Anisole)
  - stable and cheap (commercial product)

- Scintillation yield with respect to concentration of \( \text{Zr(acac)}_4 \)

- Tetakis (diethyl malonato) Zr
  - Good light yield

3. Liquid scintillator containing \( ^{92}\text{Zr} \) complex

- Detector design for \( ^{92}\text{Zr} \) loaded liquid scintillator

4. Scintillation yield with \( \beta \)-keto ester

- Liquid scintillator containing \( ^{92}\text{Zr} \) \( \beta \)-keto-ester complex
  - Absorbance
  - Scintillation light yield

Confirmed absorption peak moves

275nm \( \sim \) 245nm in Hexane, but in Acetonitrile

Observed scintillation light yield decreased (but improved). Still exist absorption peak around 270nm in Anisole ?.

- Liquid scintillator containing \( \beta \)-keto-ester ligand
  - Absorbance
  - Scintillation light yield

Absorption peaks of \( \beta \)-keto-ester ligands were found around at 240nm (not 270nm) even though the aromatic solvent. Scintillation light yield recovers almost double @ 5w.t.%

5. Zirconium (diethyl malonato) complex

- Tetrakis (diethyl malonato) Zr
  - Absorbance of ligand
  - Short absorption peak (~ 210nm)

Scintillation light yield did not decreased by the absorption at all in any concentration.

- tetrakis (diethyl malonato) Zirconium would be an ultimate complex for resolving the zirconium in a liquid scintillator.

6. Zirconium ODZ complex

- Zirconium ODZ complex
  - Molecular weight : 1040.18
  - Absorbance
  - Quantum yield : \( \sim 30\% \)

Scintillation light from PPO could be used for the emission of \( ^{92}\text{Zr}(\text{ODZ})_4 \)

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