Phasenraumfaktor und Kern-Matrixelemente für den neutrinolosen doppelten Betazerfall in ^{76}Ge

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Conversion of experimental half-life to effective electron neutrino mass in $0\nu\beta\beta$ decay

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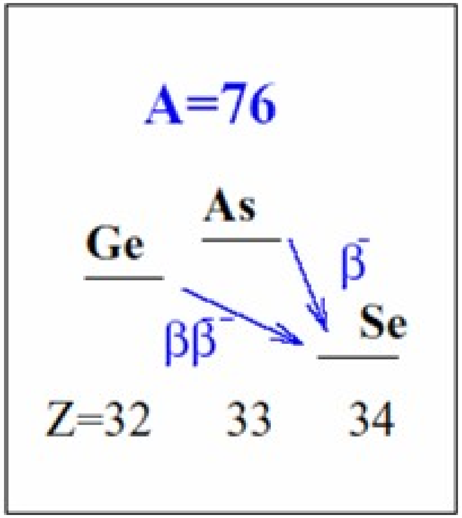
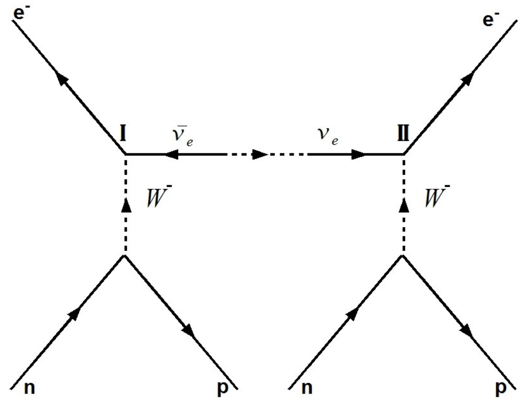
- $0\nu\beta\beta$ Zerfall im ^{76}Ge
- $T_{1/2}$ und effektive Neutrinomasse $\langle m_{\beta\beta} \rangle$
- Erwartungen für GERDA
- andere Unsicherheiten

$0\nu\beta\beta$ Zerfall in ^{76}Ge





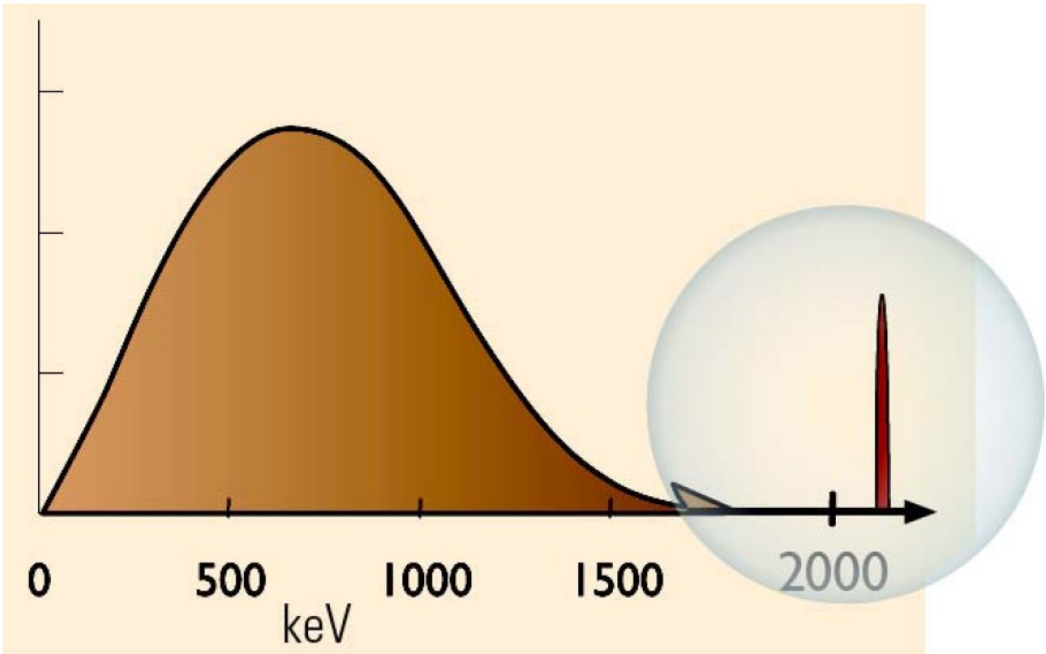
Majorana Neutrinos ?

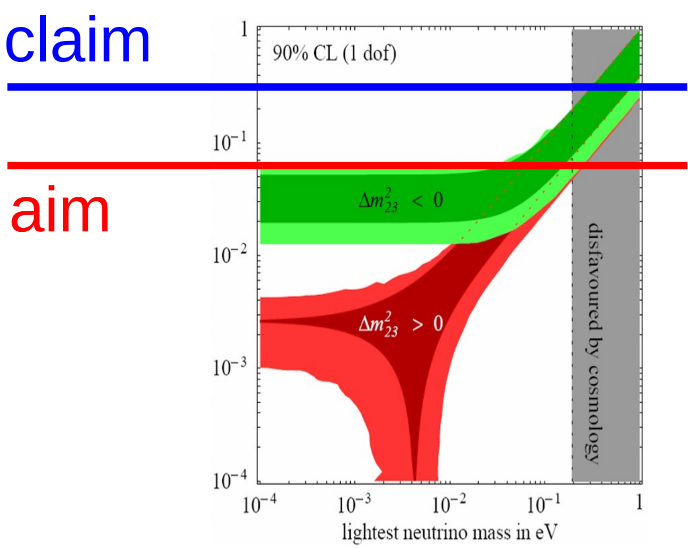
Masse der Neutrinos ?

Hierarchie ?

GERDA

peak & $T_{1/2}$





some formulas

$$\frac{1}{T_{1/2}} = G^{0\nu} |\mathcal{M}^{0\nu}|^2 \left| \frac{\langle m_{\beta\beta} \rangle}{m_e} \right|^2 = F^{0\nu} |\mathcal{M}^{0\nu}|^2 m_{\beta\beta}^2$$

Kern-Matrixelement $M^{0\nu}$: V. Rodin, F. Simkovic, A. Faessler

Phasenraumfaktor :

$$G^{0\nu} = G_{01} = \frac{a_{0\nu}}{(m_e R_A)^2 ln2} \int d\Omega_{0\nu} \; b(\varepsilon_1, \varepsilon_2)$$

Konstante : $a_{0\nu} = \frac{(G g_A)^4 \; m_e^9}{64\pi^5}$,

Integrand : (rel. Fermi-Faktor F) $b(\varepsilon_1, \varepsilon_2) = F_0(Z, \varepsilon_1) F_0(Z, \varepsilon_2)$

Differential: $d\Omega_{0\nu} = \frac{p_1\varepsilon_1 \; p_2\varepsilon_2}{m_e^5} \; \delta(\varepsilon_1 + \varepsilon_2 + M_f - M_i) \; d\varepsilon_1 d\varepsilon_2 \, d\cos\theta$

$$G^{0\nu} \sim g_A^4 \frac{1}{R_A^2}$$

radius

$R = 3,108 \times 10^{-3}\ A^{1/3}\ /\ m_e$	Doi, Kotani,Takasugi
$\sim 1.2\ A^{1/3}$	Prog.Theo.Phys.S. 83(1985)
$R = 1.1\ A^{1/3}$	Faessler
$R = 1.2\ A^{1/3}$	Suhonen,Iachello, Poves

^{76}Ge

Author	Ref.	r_0 [fm]	$G^{0\nu} \times 10^{15}$ [y^{-1}]	$\mathcal{M}'^{0\nu}$	$s \times 10^{25}$ [$eV^2 \times y]^{-1}$	Comments
Claim	[3]	1.2	6.31	4.22	4.30	
Pantis	[11]	1.1	7.93	1.34	0.55	np pairing
Simkovic	[12]	1.1	7.93	2.80	2.38	RQRPA
Simkovic	[12]	1.1	7.93	3.60	3.94	RQRPA
Rodin	[13]	1.1	7.93	3.92	4.67	RQRPA
Simkovic	[14]	1.1	7.93	3.33	3.37	Jastrow[a]
Simkovic	[14]	1.1	7.93	4.68	6.65	Jastrow[b]
Simkovic	[14]	1.1	7.93	3.92	4.67	UCOM[a]
Simkovic	[14]	1.1	7.93	5.73	9.97	UCOM[b]
Caurier	[15]	1.2	6.31	2.22	1.19	SM
Barea	[16]	1.2	6.31	5.47	7.23	IBM2-I
Barea	[16]	1.2	6.31	4.64	5.20	IBM2-II
Suhonen	[18]	1.2	6.31	2.78	1.87	Jastrow[c]
Suhonen	[18]	1.2	6.31	2.28	1.26	Jastrow[d]
Suhonen	[18]	1.2	6.31	4.11	4.08	UCOM[c]
Suhonen	[18]	1.2	6.31	3.23	2.52	UCOM[d]
Menendez	[20]	1.2	6.31	3.00	2.17	SM gcn[e]
Menendez	[20]	1.2	6.31	3.52	2.99	SM rg[e]
Simkovic	[21]	1.1	7.93	5.44	8.99	RQRPA[e]
Simkovic	[21]	1.1	7.93	4.07	5.03	RQRPA[ae]
Simkovic	[21]	1.1	7.93	6.64	13.39	RQRPA[be]

Hilfsvariable s

$$\frac{1}{T_{1/2}} = G^{0\nu}|\mathcal{M}^{0\nu}|^2 \left|\frac{\langle m_{\beta\beta}\rangle}{m_e}\right|^2 = F^{0\nu}|\mathcal{M}^{0\nu}|^2\, m^2_{\beta\beta}$$

$$s = G^{0\nu}|\mathcal{M}'^{0\nu}|^2 m_e^{-2} \quad [\mathrm{eV}^2 y]^{-1}$$

$$\langle m_{\beta\beta}\rangle = (s T_{1/2})^{-1/2}$$

Renormierung auf g_A

eff. Neutrinomassen in [meV]

$$\langle m_{\beta\beta} \rangle = (s T_{1/2})^{-1/2}$$

Author	Ref.	$s \times 10^{25}$ $[eV^2 \times y]^{-1}$	$T_{1/2} \times 10^{-25}$ [y]				
			1.2	2.2	3	15	20
			Claim	Phase I		Phase II	
Menendez	[20]	2.99	528	390	334	149	129
Suhonen	[18]	4.08	452	334	286	128	111
Rodin	[13]	4.67	422	312	267	119	103
Barea	[16]	7.23	340	251	215	96	83
Simkovic	[21]	8.99	304	225	193	86	75

recommendation

Experimental sensitivity	Ref.	$T_{1/2}$ $[10^{-25}\ y]$	$\langle m_{\beta\beta} \rangle$ [eV]
Claim	[3]	1.2	0.30–0.53
GERDA Phase I	[1]	2.2	0.23–0.39
GERDA Phase II	[1]	15.0	0.09–0.15

[1] GERDA proposal http://www.mpi-hd.mpg/gerda/proposal.pdf
[3] H.V. Klapdor-Kleingrothaus et al., Phys. Lett. B586 (2004) 198

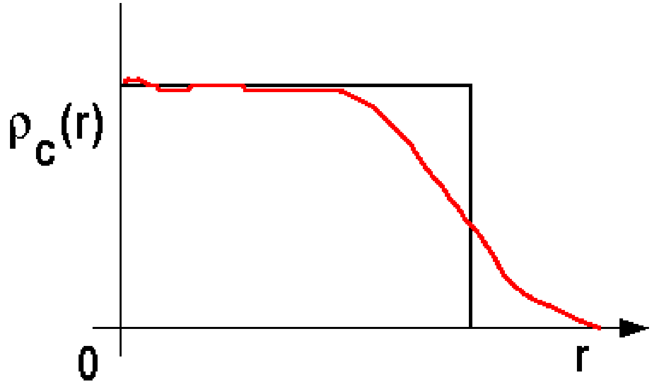
offene Fragen

Fermi Funktion F_0 & Integrand $b(\varepsilon_1,\varepsilon_2)$

$$b(\varepsilon_1, \varepsilon_2) = F_0(Z, \varepsilon_1) F_0(Z, \varepsilon_2)$$

Annahme: 1) $2e^-$ Emission instantan
2) Distortion durch dieselbe Z-Verteilung

F_0 mit 'harte Kugel' - Verteilung berechnet



Dirac Gl. in Potential $V(r)$ gemäß $\rho_c(r)$

Doi etc.: nicht wichtig (wenige %) (vgl. in ^{12}B)

Zusammenfassung

Phasenraumfaktor mit vielen Näherungen berechnet

Primakoff & Rosen NR Näherung
'harte Kugel'
kein Screening

Hier nur Phasenraumfaktor für Majorana-Anteil !!

Nicht nur Kern-Matrixelemente haben Unsicherheiten

GERDA

beginnt zu messen (S. Schönert HK13.1, Di 8:30)
Phase II wird $\langle m_{\beta\beta} \rangle \sim 100$ meV erreichen