Possible neutron scattering search for new spin-dependent interactions in the Femtometer range

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Axions and axion-like interactions:

S. Weinberg, Phys. Rev. Lett. 40 (1978) 223

F. Wilczek, Phys. Rev. Lett. 40 (1978) 279

J.E. Moody, F. Wilczek
Phys. Rev. D30 (1984) 130

$$m_a f_a = m_\pi f_\pi \sqrt{z}/(z+1)$$

$m_\pi = 135\,\mathrm{MeV}$ $z = m_u/m_d = 0.56$ $f_\pi \approx 93\,\mathrm{MeV}$

$$m_a\,(\mathrm{eV}) \approx 6 \times 10^6 / f_a\,(\mathrm{GeV})$$

$$g_{aff} = C_f m_f / f_a$$

Laboratory searches for the axion

$$n + {}^{10}\mathrm{B} \to {}^{7}\mathrm{Li}^{*} + \alpha$$

$$\hookrightarrow {}^{7}\mathrm{Li} + a$$

$$n + p \to d + a$$

$$J/\psi \to \gamma + a\,(\text{invisible})$$

$$\Upsilon \to \gamma + a\,(\text{invisible})$$

$$K^{+} \to \pi^{+} + a\,(\text{invisible})$$

$$B^{+} \to K^{+} + a\,(\text{invisible})$$

$$\pi^{+} \to e^{+} + \nu_e + a\,(a \to e^{+}e^{-})$$

$$(10^{-5} < m_a < 10^{-3})\,\mathrm{eV}$$

New arguments in favor of existence of MeV mass of axions or U-bosons

- **R. Essig et al., arXiv:1008.0636;** ***new experiments***
- **J.D. Bjorken et al., Phys. Rev. D80 (2009) 075018** ***new experiments***

- **J. Blumlein, J. Brunner, Phys. Lett. B701 (2011) 155** ***reprocessing***

- **A.V. Derbin et al., arXiv:1007.3387** ***solar axions in***
- **G. Bellini et al., (Borexino Coll.) arXiv:1203.6258** ***MeV mass range***

- **Z. Berezhiani, A. Drago, Phys. Lett. B573 (2000) 281** ***gamma bursts***

- **C. Boehm, P.Fayet, Phys. Lett. B683 (2004) 219** ***dark matter***
- **C. Boehm et al, Phys. Rev. Lett. 92 (2004) 101301** ***dark matter***

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A REEVALUATION OF EVIDENCE FOR LIGHT NEUTRAL BOSONS IN NUCLEAR EMULSIONS*

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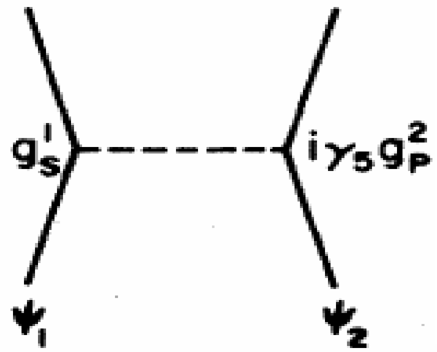


$$U(\mathbf{r}) = (\boldsymbol{\sigma}\cdot\boldsymbol{n})\frac{g_s g_p \hbar^2}{8\pi m_n}\left(\frac{1}{\lambda r}+\frac{1}{r^2}\right)e^{-r/\lambda}$$

$$f_a(\boldsymbol{q}) = -i g_s g_p N \frac{\boldsymbol{\sigma}\cdot\boldsymbol{n_q}}{4\pi}\frac{q\lambda^2}{1+(q\lambda)^2}$$

$$q = 1/\lambda$$

$$f_a(\lambda) = \frac{\pm i g_s g_p N\lambda}{8\pi}$$

$(10 < E_n < 10^6)$ eV $\quad (3 < \lambda < 10^3)$ F $\quad (0.2 < m_a < 70)$ MeV.

$$f(q) = f_0(q) + f_1(q) + f_{\text{Sch}}(q) + f_{n-e}(q) + f_p(q) + f_a(q)$$

$$f_{\text{Sch}} = i\frac{\mu_n Z e^2}{2m_n c^2}\frac{(\boldsymbol{\sigma}[\boldsymbol{k}\boldsymbol{k}_0])}{kk_0}ctg(\frac{\phi}{2})$$

$$\frac{d\sigma^{\pm}}{d\Omega} \approx |Ref_0 + i\cdot Imf_0 + Ref_1 + i\cdot Imf_1 \pm i\cdot|f_a||^2 \approx$$
$$\approx (Ref_0 + Ref_1)^2 + (Imf_0 + Imf_1)^2 \pm 2\,(Imf_0 + Imf_1)\,|f_a|$$
$$\approx \frac{\sigma_{tot}}{4\pi} \pm 2\,(Imf_0 + Imf_1)\,|f_a| = \frac{\sigma_{tot}}{4\pi} \pm 2\,Imf\,|f_a|.$$

$$A = \frac{d\sigma^+/d\Omega - d\sigma^-/d\Omega}{d\sigma^+/d\Omega + d\sigma^-/d\Omega} = \frac{8\pi Imf \cdot |f_a|}{\sigma_{tot}} =$$

$$g_s g_p \frac{Imf \cdot N\lambda}{\sigma_{tot}} = g_s g_p B\lambda \qquad B = Imf \cdot N/\sigma_{tot}$$

$$g_s g_p = A\frac{\sigma_{tot}}{Imf \cdot N\lambda} = \frac{A}{B\lambda}$$

σ_{tot}=10 b Imf=5 Fm N=200 B=10 Fm^{-1} A =10^{-4}

$g_s g_p \sim 10^{-6}$ at $\lambda = 10$ Fm

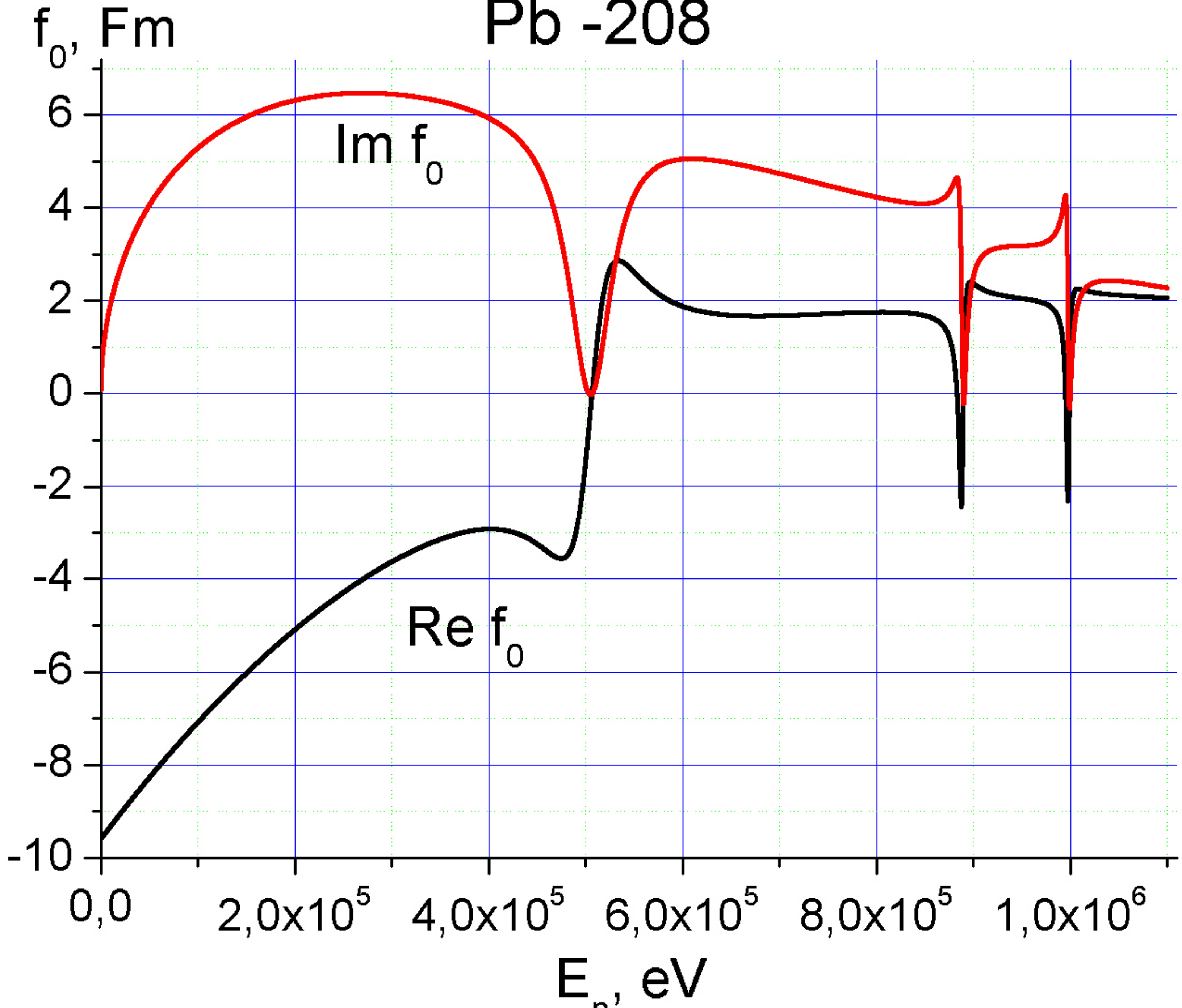
$$f_0 = \frac{i}{2k}(1 - S_0) \qquad S_0 = e^{2i\delta_0}\left(1 - \sum_j \frac{ig_j\Gamma_{nj}}{(E - E_j) + i\Gamma_j/2}\right)$$

$$\Gamma_{nj} = \Gamma_{nj}(E_j)k/k_j,\ \Gamma_j = \Gamma_{nj} + \Gamma_{\gamma j},$$

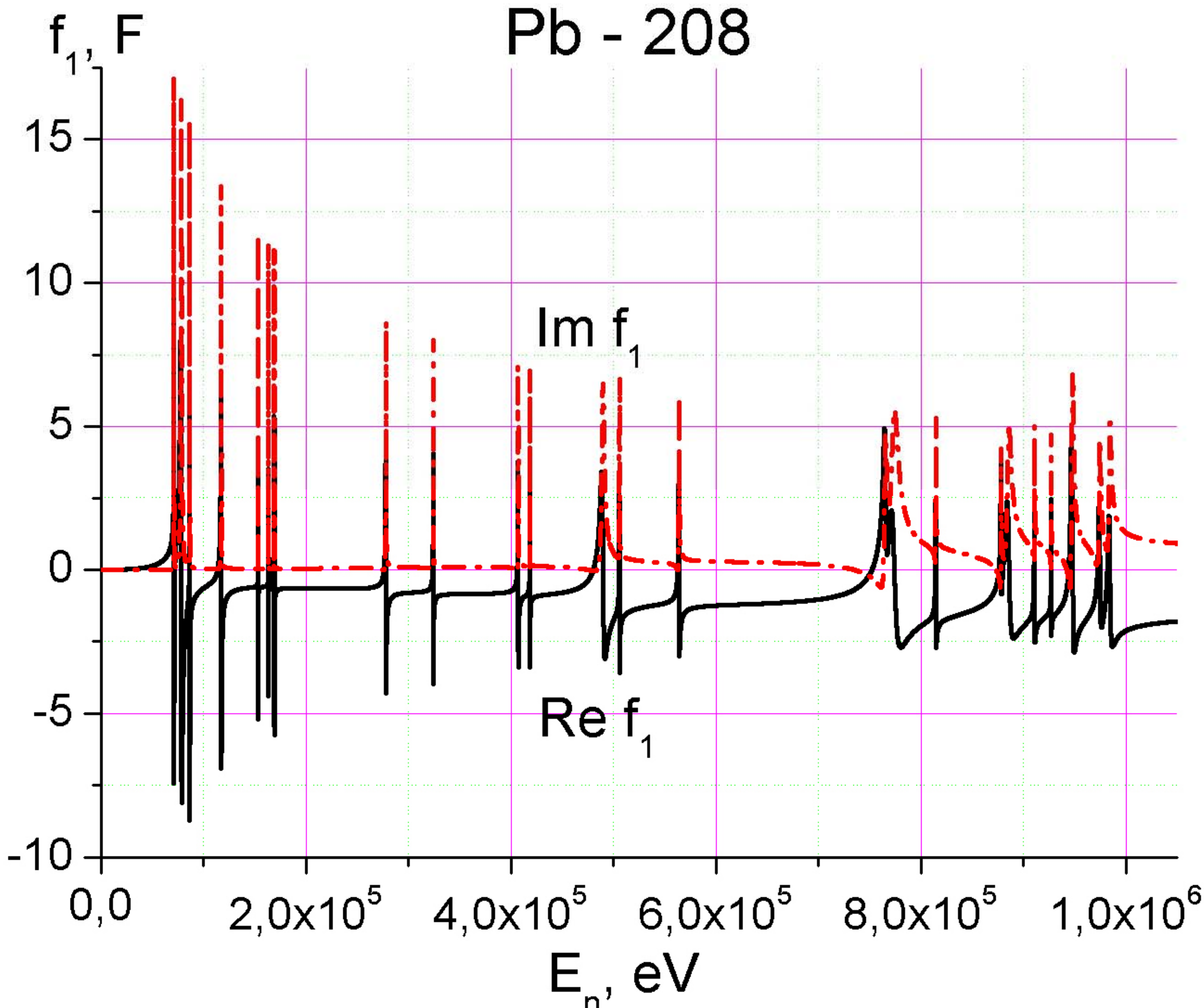
$$\sum\nolimits_{(1)} = \sum_j \frac{2}{k_j}\frac{g_j\Gamma_{nj}(E - E_j)}{4(E - E_j)^2 + \Gamma_j^2} \qquad \sum\nolimits_{(2)} = \sum_j \frac{1}{k_j}\frac{g_j\Gamma_{nj}\Gamma_j}{4(E - E_j)^2 + \Gamma_j^2}$$

$$\mathrm{Re} f_0 = \frac{\sin(2\delta_0)}{2k} - \cos(2\delta_0)\sum\nolimits_{(1)} - \sin(2\delta_0)\sum\nolimits_{(2)}$$

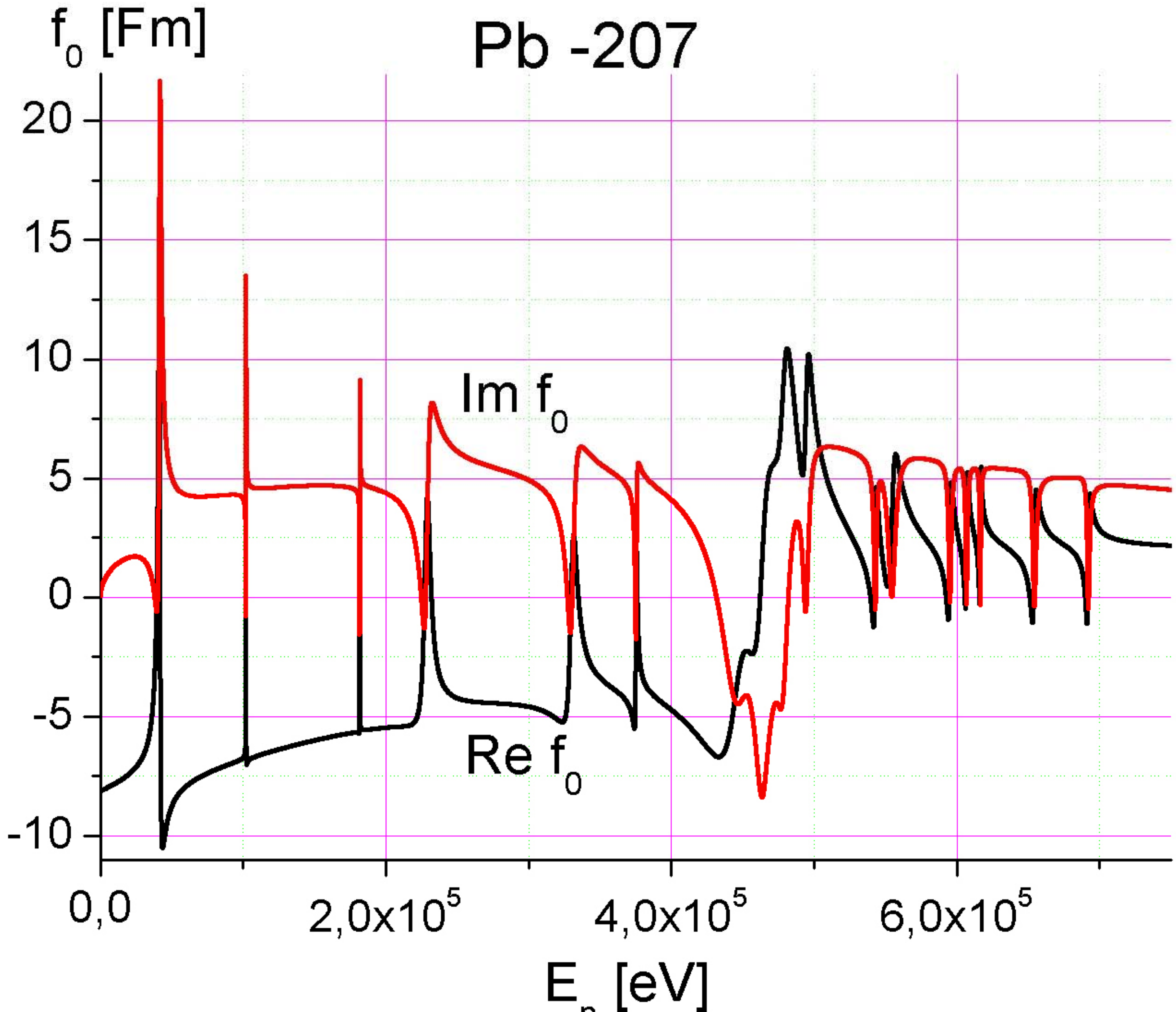
$$\mathrm{Im} f_0 = \frac{\sin^2\delta_0}{k} + \cos(2\delta_0)\sum\nolimits_{(2)} - \sin(2\delta_0)\sum\nolimits_{(1)}$$



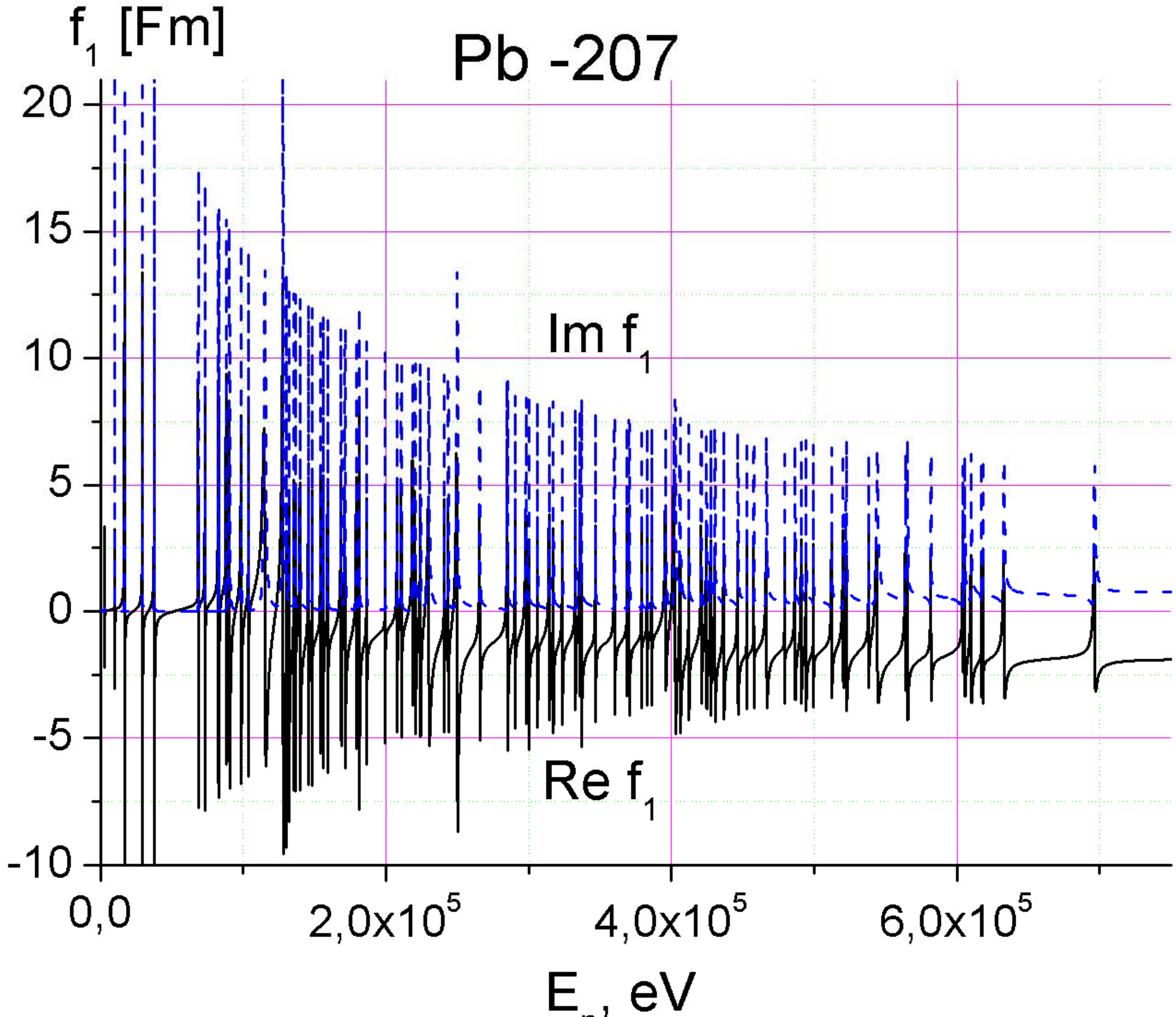
Pb -208
f0, Fm
Im f0
Re f0
6
4
2
0
-2
-4
-6
-8
-10
0,0
2,0x10^5
4,0x10^5
6,0x10^5
8,0x10^5
1,0x10^6
En, eV



Pb - 208
f1, F
15
10
5
0
-5
-10
Im f1
Re f1
0,0
2,0x10^5
4,0x10^5
6,0x10^5
8,0x10^5
1,0x10^6
En, eV



f0 [Fm]
Pb -207
Im f0
Re f0
20
15
10
5
0
-5
-10
0,0
2,0x10^5
4,0x10^5
6,0x10^5
En [eV]



f1 [Fm]
Pb -207
Im f1
Re f1
20
15
10
5
0
-5
-10
0,0
2,0x10^5
4,0x10^5
6,0x10^5
En, eV

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Neutron diffraction test on spin-dependent short range interaction

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