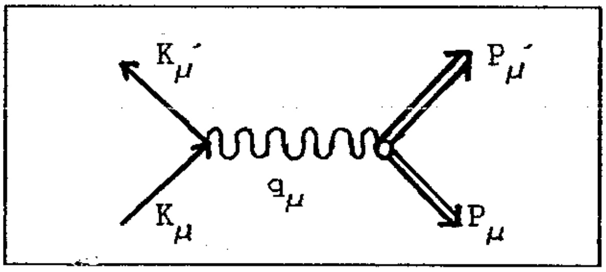
LAMPIRAN-1

PENURUNAN TAMPANG-LINTANG HAMBURAN ELEKTRON INTI



Gb. 2. 1. Diagram Interaksi Elektron-Inti Feynman

Didefinisikan :

$P_\mu \equiv (\vec{P}, iE)$ ....(L.1.1a)

$K_\mu \equiv (\vec{K}, i\epsilon)$ ....(L.1.1b)

$q_\mu \equiv (K'-K)_\mu$ ....(L.1.1c)

$P^2 \equiv -M_T^{\ 2}$; $P_\mu^{\ 2} = -M_T^{\ 2}$ ....(L.1.1d)

Elektron datang dengan energi momentum-empat inti K_μ terhambur dengan sudut hamburan θ ke state akhir, dengan momentum-empat inti P_μ' sehingga mengakibatkan transisi inti sasaran dari state awal $|i\rangle = |J_i\ M_i\rangle$ ke state akhir $|f\rangle = |J_f\ M_f\rangle$.

Diasumsikan bahwa inti sasaran pada titik ini terdapat operator rapat arus inti lokal $\hat{J}_\mu(\vec{x},t)$, yang menimbulkan potensial elektromagnet inti. Rapat arus inti diberikan oleh persamaan :

$J_\mu(x) = \langle f|\hat{J}_\mu(x)|i\rangle$ ....(L.1.2a) dan memenuhi hubungan transisi rapat arus inti melalui persamaan-persamaan Maxwell :

$$\Box A_\mu^{ext}(\vec{x},t) = -e_p\ J_\mu(x) = -e_p \langle f|\hat{J}_\mu(\vec{x},t)|i\rangle$$

$$= e_p \langle f|\hat{J}_\mu(x)|i\rangle \exp[-i(E-E')t]$$

...........(L.1.2b)

dengan:

$\hat{J}_\mu(x) =$ $[\hat{J}(x), i\hat{\rho}(x)]$ merupakan operator rapat arus vektor-empat.

$A_\mu^{ext} =$ $\{\vec{A}(x), i\varphi(x)\}$ yang merupakan potensial elektromagnet vektor-empat di titik koordianat ruang-waktu $x_\mu = (\vec{x}, it)$

Operator Hamiltonian interaksi gayut-waktu elektron-inti ditulis sebagai :

$$\hat{\mathcal{H}}_i(x) = -e\hat{j}_\mu(x)\ \hat{A}_\mu^{ext}(x) = -ie\bar{\psi}(x)\ \gamma_\mu\ \psi(x)\ A_\mu^{ext}(x)$$

........(L.1.3)

dengan :

γ_μ adalah matrik Dirac.

$J_\mu(x) = i\bar{\psi}(x)\ \gamma_\mu\ \psi(x)$ merupakan operator rapat arus elektron.

Untuk menggambarkan interaksi elektron, kita memerlukan operator hamburan $\hat{S}$ orde terendah :

$$\hat{S} = -i\int \hat{\mathcal{H}}_i^{(0)}(x,t)\ d^4x\ . \qquad ......(L.1.4)$$

Elemen matrik hamburan yang dibutuhkan antara state elektron awal dan akhir serta state inti awal dan akhir diberikan oleh :

$$S = \langle 1_{\vec{k}',\lambda'}; J_f M_f | \hat{S} | 1_{\vec{k},\lambda}; J_i M_i \rangle$$

$$= -e \int \langle 1_{\vec{k}',\lambda'} | \bar{\psi}(x)\, \gamma_\mu\, \psi(x) | 1_{\vec{k},\lambda} \rangle$$

$$\langle J_f M_f | \hat{A}_\mu(x) | J_i M_i \rangle\ d^4x \qquad \text{........(L.1.5)}$$

Dengan menuliskan ekspansi operator spinor elektron ke dalam operator pelennyap dan operator pencipta berdasarkan teori kuantisasi kedua :

$$\psi(x) = (m/\epsilon V)^{1/2} \sum_{\vec{k}} \sum_{\lambda} \{ U_\lambda(\vec{k})\ \hat{a}_{k,\lambda}\ \exp(ik_\mu \cdot x_\mu)$$

$$+ V_\lambda(k)\ \hat{b}_{k,\lambda} \exp(-ik_\mu . x_\mu)\} \qquad \text{.........(L.1.6a)}$$

$$\bar{\psi}(x) = (m/\epsilon V)^{1/2} \sum_{\vec{k}'} \sum_{\lambda'} \{ \bar{U}_{\lambda'}(\vec{k}') \hat{a}_{k',\lambda'}\ \exp(-ik_\mu \cdot x_\mu)$$

$$+ V_{\lambda'}(k)\ \hat{b}_{k',\lambda'} \exp(-ik'_\mu\ . x_\mu)\} \qquad \text{........(L.1.6b)}$$

dengan :

$$k_\mu \cdot x_\mu = k \cdot x - Et$$

sehingga persamaan (L.1.5) menjadi :

$$S = \frac{-e^2 m}{V(\epsilon\epsilon')^{1/2}} \int U_{\lambda'}(k')\ \gamma_\mu U_\lambda(k)\ \exp(-iq_\mu \cdot x_\mu) A_\mu(x)\ d^4x$$

$$\text{.............(L.1.7)}$$

dengan faktor normalisasi U dilampirkan pada Lampiran-4.

Transformasi Fourier persamaan (L.1.2b) berbentuk :

$$q_\mu^2 \int \exp(-iq_\mu \cdot x_\mu) A_\mu(x)\, d^4x = e\int \exp(-iq_\mu \cdot x_\mu)\ J_\mu(x) d^4x$$

.... (L.1.8)

Sehingga persamaan (L.1.7) dapat disajikan dalam bentuk :

$$S = \frac{-e^2 m}{V(\epsilon\epsilon')^{1/2}}\ U_{\lambda'}(k')\ \gamma_\mu U_\lambda(k) \int \exp(-iq_\mu \cdot x_\mu) q_\mu(x)\ d^4x$$

.... (L.1.9)

Dengan menggunakan :

$$J_\mu(x) = J_\mu(x)\ \exp\{i(E'-E)t\} \qquad \text{.......(L.1.10a)}$$

$$\exp(-iq_\mu \cdot x_\mu) = \exp\{i(\epsilon'-\epsilon)t\}\ \exp(-iq_\mu \cdot x)$$

....(L.1.10b)

maka persamaan (L.1.9) menjadi :

$$S = \frac{-e^2 m}{q^2_\mu V(\epsilon\epsilon')^{1/2}}\ U_{\lambda'}(k')\ \gamma_\mu U_\lambda(k)\ J_\mu(q)(2\pi)\delta(E'+\epsilon'-E-\epsilon)$$

.........(L.1.11)

dengan :

$$J_\mu(q) = \int \exp(-iq)\ J_\mu(x)\ d^3x \qquad \text{.........(L.1.12a)}$$

$$\int \exp\{\ i(E'+\epsilon'-E-\epsilon)t\ \}\ dt = 2\pi\delta((E'+\epsilon'-E-\epsilon)$$

.........(L.1.12b)

Kebolehjadian transisi persatuan waktu, diberikan oleh :

$$\frac{|S|^2}{T} = \frac{e^4 m^2}{q^4\ V^2 \epsilon\epsilon'}\, 2\pi\delta(E'+\epsilon'-E-\epsilon)\left|\ U_{\lambda'}(k')\gamma_\mu U_\lambda(k) J_\mu(q)\right|^2$$

.......(L.1.13)

dengan :

$$\left|\ \delta(E'+\epsilon'-E-\epsilon)\ \right|^2 = \frac{T}{2\pi}\,\delta(E'+\epsilon'-E-\epsilon) \qquad ......(L.1.14)$$

Jika fluks elektron datang $(1/V)(|k|/\epsilon)$, maka tampang-lintang hamburannya adalah :

$$d^2\sigma = \frac{|S|^2}{T}\,\frac{Vd^3k'}{(2\pi)^3}\,\frac{Vd^3P}{(2\pi)^3}\,\frac{1}{(|k|)/(\epsilon V)} \qquad ....(L.1.15)$$

$$d^2\sigma = \frac{4\alpha^2 m^2}{q_\mu^{\ 4}\epsilon'|k|}\ \delta(E'+\epsilon'-E-\epsilon)\,|u_\lambda(k')\gamma_\mu U_\lambda(k)|^2\ d^3k'$$

$$\times\ \frac{Vd^3P}{(2\pi)^3}\ J_\mu(q)J_\nu^{\ *}(q) \qquad ....(L.1.16)$$

Dari hubungan :

$$d^3k' = |k'|^2 dk' d\Omega = |k|\epsilon' d\epsilon' d\Omega \qquad .....(L.1.17)$$

diperoleh prsamaan :

$$\frac{d^2\sigma}{d\epsilon' d\Omega} = \frac{4\alpha^2 m^2}{q_\mu^{\ 4}\,\epsilon'|k|}\ |\bar{U}_{\lambda'}(k')\gamma_\mu U_\lambda(k)|^2\ (|\vec{k}'|)\epsilon' d\epsilon' d\Omega)$$

$$\times\ \frac{Vd^3P}{(2\pi)^3}\ \delta(E'+\epsilon'-E-\epsilon)J_\mu(q)J_\nu^{\ *}(q) \qquad ......(L.1.18)$$

dengan pendekatan secara relativistik berlaku $m \approx 0$ atau $|k'| = \epsilon'$ dan $|k| = \epsilon$, maka :

$$\frac{d^2\sigma}{d\epsilon' d\Omega} = \frac{4\alpha^2 m^2}{q^4(\epsilon/\epsilon')} |U_{\lambda'}(k')\gamma_\mu U_\lambda(k)|^2 \frac{Vd^3P}{(2\pi)^3}\delta(E'+\epsilon'-E-\epsilon)$$

$$x\ J_\mu(q)J_\nu^*(q) \qquad ......(L.1.19)$$

Untuk hamburan yang tidak terpolarisasi dilakukan pereratan terhadap λ dan penjumlahan yang meliputi λ', maka :

$$\left(\frac{d^2\sigma}{d\epsilon' d\Omega}\right)_{tp} = 1/2 \sum_\lambda \sum_{\lambda'} \frac{d^2\sigma}{d\epsilon' d\Omega} \qquad ......(L.1.20)$$

sehingga diperoleh bentuk :

$$\frac{d^2\sigma}{d\epsilon' d\Omega} = \frac{4\alpha^2 m^2}{q^4(\epsilon/\epsilon')} |U_{\lambda'}(k')\gamma_\mu U_\lambda(k)|^2 \frac{Vd^3P}{(2\pi)^3}\delta(E'+\epsilon'-E-\epsilon)$$

$$x\ J_\mu(q)J_\nu^*(q) \qquad ....(L.1.21)$$

Faktor $|U_{\lambda'}(k')\gamma_\mu U_\lambda(k)|^2$ sesudah dikenai penjumlahan akan menghasilkan bentuk *trace* sehingga konstantanya akan mengeliminasi m^2 (Lampiran-4), sehingga n pe r samaan (L.1.21) menjadi :

$$\left(\frac{d^2\sigma}{d\epsilon' d\Omega}\right)_{tp} = \frac{\alpha^2}{q_\mu^4} \frac{\epsilon'}{\epsilon} \eta_{\mu\nu} W_{\mu\nu} \qquad ......(L.1.22)$$

dengan :

$$\eta_{\mu\nu} \equiv -1/2\ T_r\ \{\ \gamma_\mu(m-i\gamma\cdot k)\gamma_\nu(m-i\gamma\cdot k')\ \}$$

$$= 2(\ k_\mu k_\nu' + k_\nu k_{\mu'} + 1/2\ q_\mu^2\ \delta_{\mu\nu}\ ) \qquad ....(L.1.23)$$

yang didefinisikan sebagai faktor bentuk lepton.

$$W_{\mu\nu} \equiv - \frac{Vd^3P}{(2\pi)^3} \delta(E'+\epsilon'-E-\epsilon) J_\mu(q) J_\nu^*(q) \quad ....(L.1.24)$$

yang didefinisikan sebagai faktor bentuk hadron.

Invariansi Lorentz menyatakan bahwa "$W_{\mu\nu}$ harus merupakan suatu tensor rank-2" karena operator arus elektromagnet merupakan vektor-empat. Karena jumlahan yang meliputi state awal dan state akhir , maka hanya ada dua vektor-empat yang dapat gayut, yakni q_μ dan q_ν. Dua skalar tak gayut yang dapat dibentuk dari kedua vektor-empat tersebut adalah :

$$q_\mu^2 \text{dan} \quad q.P \equiv q.P + q_4 q_4,$$

sehingga bentuk umum tensor $W_{\mu\nu}$ dapat dituliskan sebagai :

$$W_{\mu\nu} = \delta_{\mu\nu} A(q_\mu^2; q \cdot P) + q_\mu q_\nu B(q_\mu^2; q \cdot P)$$

$$+ P_\mu P_\nu C(q_\mu^2; q \cdot P) + (q_\mu P_\nu + q_\nu P_\mu)\, D\, (q_\mu^2; q \cdot P)$$

$$+ (q_\mu P_\nu - q_\nu P_\mu)\, E\, (q_\mu^2; q \cdot P) \quad .....(L.1.25)$$

Dari persamaan kontinuitas arus inti :

$$\frac{\partial}{\partial x_\mu} J_\mu(x) = 0 \quad ....(L.1.26)$$

dan pada persamaan (L.1.25) berlaku :

$$q_\mu W_{\mu\nu} = W_{\mu\nu}\, q_\nu = 0 \quad ....(L.1.27)$$

sehingga diparoleh 4 persamaan yang saling gayut :

$$(1)\quad A(q_\mu^2; q\cdot P) + q_\mu^2 B(q_\mu^2; q\cdot P) + q_\mu^2 D(q_\mu^2; q\cdot P) + E(q_\mu^2; q\cdot P) = 0 \qquad .....(L.1.28a)$$

$$(2)\quad q\cdot PC(q_\mu^2; q\cdot P) + q_\mu^2 D(q_\mu^2; q\cdot P) + E(q_\mu^2; q\cdot P) = 0 \qquad ....(L.1.28b)$$

$$(3)\quad A(q_\mu^2; q\cdot P) + q_\mu^2 B(q_\mu^2; q\cdot P) + q_\mu P\, D(q_\mu^2; q\cdot P) = 0 \qquad .....(L.1.28c)$$

$$(4)\quad q\cdot PC(q_\mu^2; q\cdot P) + q_\mu^2 D(q_\mu^2; q\cdot P) - E(q_\mu; q\cdot P) = 0 \qquad ....(L.1.28d)$$

Dengan menuliskan $A(q_\mu^2; q\cdot P) = W_1$ dan $C(q_\mu^2; q\cdot P) = W_2/M^2$

maka secara umum $W_{\mu\nu}$ dapat ditulis sebagai :

$$W_{\mu\nu} = \left(\delta_{\mu\nu} - \frac{q_\mu q_\nu}{q_\mu^2}\right) W_1 \left(P_\mu - \frac{q\,.P}{q_\mu^2} q_\mu\right)\left(P_\mu - \frac{q\,.P}{q_\mu^2} q_\nu\right) \frac{W_2}{M^2} \qquad ....(L.1.29)$$

dengan W_1 dan W_2 merupakan faktor-faktor bentuk hadron yang invarian.

Hasil dari perhitungan perkalian faktor bentuk lepton dan hadron (lihat Lampiran-5) menyebabkan tampang lintang hamburan pada persamaan (L.1.22) menjadi :

$$\left(\frac{d\sigma^2}{d\epsilon' d\Omega}\right)_{ip} = \frac{\alpha\ \epsilon'^2}{q_\mu^4\ \epsilon}\left[2(q_\mu^2-2m^2)W_1 + \left\{\frac{2(k\cdot P)(k'\cdot P)}{M^2} - 1/2q_\mu^2\right\}2W_2\right]$$

...........(L.1.30)

Dengan mengabaikan massa elektron dan efek *recoil*, didapatkan hubungan-hubungan sebagai berikut :

$$q_\mu^2 = (k'-k_\mu)^2 = (k')^2 + (k)^2 - 2k\cdot k'$$

$$= (-m^2) + (-m^2) - 2\epsilon\epsilon'(\cos\theta-1) \approx 4\epsilon\epsilon'\sin^2\frac{\theta}{2}$$

.....(L.1.31a)

$$2(q_\mu^2-2m^2) \approx 8\epsilon\epsilon'\sin^2\frac{\theta}{2}$$ .....(L.1.31b)

$$\left\{\frac{4(k\cdot P)(k\cdot P)}{M^2} - q_\mu^2\right\} \approx 4\epsilon\epsilon'\cos^2\frac{\theta}{2}$$ .....(L.1.31c)

Sehingga persamaan (L.1.33) menjadi :

$$\left(\frac{d^2\sigma}{d\epsilon' d\Omega}\right)_{ip} = \sigma_M \frac{\epsilon}{\epsilon'}\left(W_2 + 2\tan^2\frac{\theta}{2}W_1\right)$$ .....(L.1.32)

yang merupakan formula Rusenbluth untuk interaksi elektron-inti,

dengan :

$$\sigma_M = \frac{\alpha^2\cos^2\frac{\theta}{2}}{4\epsilon\epsilon'\sin^4\frac{\theta}{2}}$$ merupakan tampang-lintang hamburan Mott untuk inti berbentuk titik.

Analisis Multipol Arus Elektromagnet

Tampang lintang interaksi elektron-inti pada persamaan (L.1.17) per satuan *phase-space* yang tersedia untuk inti *recoil* dapat diperoleh dengan mengintegrasikan $d^2\sigma$ meliputi $d\epsilon'$ dengan faktor *Delta Dirac* masih tetap ada. Hasilnya adalah :

$$(d\sigma)_{tp} = d\Omega \frac{\alpha^2}{q_\mu^4}\frac{\epsilon'}{\epsilon} 1/2 T_r\{\gamma_\mu(m-i\gamma\cdot k)\gamma_\nu(m-i\gamma\cdot k')\}$$

$$\times J_\mu(\vec{q})J_\nu^*(\vec{q}) \qquad \text{.........(L.1.33)}$$

$$\left(\frac{d\sigma}{d\Omega}\right)_{tp} = \frac{2\alpha^2}{q_\mu^4} \cdot 2(k_\mu k_\nu' + k_\mu' k_\nu + 1/2 q_\mu^2 \delta_{\mu\nu})\ J_\mu(\vec{q})J_\mu(\vec{q})$$

$$\text{......(L.1.34)}$$

Jika didefinisikan :

$$Q_\mu \equiv 1/2(k'+k)_\mu \qquad \text{.......(L.1.35a)}$$

$$q_\mu \equiv (k'-k)_\mu \qquad \text{......(L.1.35b)}$$

maka diperoleh :

$$4Q_\mu Q_\nu - q_\mu q_\nu = 2(K_\mu k_\nu' + k_\mu' k_\nu') \qquad \text{......(L.1.35c)}$$

daari substitusi persamaan (L.1.35c) ke persamaan (L.1.34) akan menghasilkan :

$$\left(\frac{d\sigma}{d\Omega}\right)_{tp} = \frac{2\alpha^2}{q_\mu^4} \cdot \frac{\epsilon'}{\epsilon} \cdot (2Q_\mu Q_\nu - 1/2 q_\mu q_\nu + 1/2 q_\mu^2 \delta_{\mu\nu}) J_\mu(\vec{q}) J_\nu(\vec{q})$$

$$= \frac{2\alpha^2}{q_\mu^4} \cdot \frac{\epsilon'}{\epsilon} \cdot \Big\{ 2(J_\mu(\vec{q})Q_\mu)(J_\nu^*(\vec{q})Q_\nu - 1/2\, q_\mu J_\mu(\vec{q})q_\nu J_\nu^*(\vec{q}) + 1/2\, q_\mu^2 J_\nu(\vec{q})J_\nu^*(\vec{q}) \Big\}$$

.......(L.1.36)

Dari persamaan kontinuitas arus inti persamaan (L.1.26) diperoleh :

$$q_\mu J_\mu(\vec{q}) = q_\mu \int \exp(-i\vec{q}.\vec{x})\ J_\mu(\vec{x})\ d^3x$$

$$= \frac{i}{|\vec{q}|}\, q_\mu \frac{\partial}{\partial x_\mu} \int \exp(i\vec{q}.\vec{x})\ J_\mu(\vec{x})\ d^3x$$

$$= \frac{i}{|\vec{q}|}\, q_\mu \int \exp(-i\vec{q}.\vec{x}) \Big\{ \frac{\partial}{\partial x_\mu} J_\mu(\vec{x}) \Big\}\ d^3x = 0$$

sehingga persamaan (L.1.36) menjadi :

$$\left(\frac{d\sigma}{d\Omega} \right)_{ip} = \frac{2\alpha^2}{q_\mu^4} \cdot \frac{\epsilon'}{\epsilon} \cdot \Big\{ 2(J_\mu(\vec{q})Q_\mu)(J_\nu^*(\vec{q})Q_\nu + 1/2 q_\nu^2 J_\nu(\vec{q})J_\nu^*(\vec{q}) \Big\}$$

........(L.1.37)

Rerata yang melingkupi state awal dan penjmlahan yang melingkupi state akhir dengan bilangan kuantum (JM) :

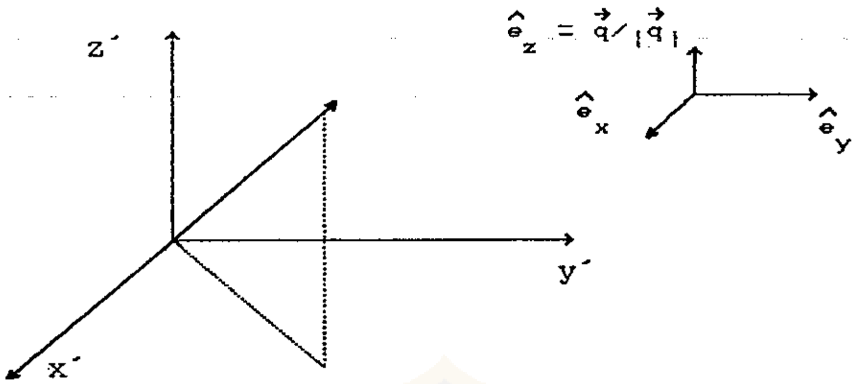
$$\sum_i \sum_f \longleftrightarrow \frac{1}{2J_i+1} \sum_{M_i} \sum_{M_f} \text{ memberikan :}$$

$$m = \frac{1}{2J_i+1} \sum_{M_i} \sum_{M_f} \Big\{ 2(J_\mu(\vec{q})Q_\mu)(J_\nu^*(\vec{q})Q_\nu + 1/2 q_\mu^2\ J_\nu(\vec{q}) J_\nu^*(\vec{q}) \Big\}$$

$$= \frac{1}{2J_i+1} \sum_{M_i}\sum_{M_f} \left\{ 2(\vec{J}\cdot\vec{Q}-Q_o)(\vec{J}^{*}\cdot\vec{Q}-\rho_{\mu}^{*}\,Q_o) + 1/2q_{\mu}^{2}(\vec{J}\cdot\vec{J}^{*}-\rho\cdot\rho^{*}) \right\}$$

......(L.1.38)

Dalam basis bola didefinisikan :



$\hat{e}_{\lambda} = \hat{e} \pm 1 = \mp 1/\sqrt{2}\ (\hat{e}_x \pm i\hat{e}_y)$ ....(L.1.39a)

$\hat{e}_o = \hat{e}_z = \hat{e}_o^{*}$ ....(L.1.39b)

dengan sifat-sifat :

$\hat{e}_{\lambda}^{*}\cdot\hat{e}_{\lambda'} = \delta_{\lambda\lambda'}$ ....(L.1.39c)

Sehingga komponen $\bar{J}$ dapat dituliskan dalam basis tersebut sebagai :

$J_{\mu}(\vec{q}) = \sum_{\lambda} J_{\lambda}(\vec{q})\hat{e}_{\lambda}^{*}$ ....(L.1.40a)

$J_{\mu}(\vec{q}) = \hat{e}_{\lambda}\cdot J_{\mu}(\vec{q}) = \hat{e}_{\lambda}\cdot\int \exp(-i\vec{q}\cdot\vec{x})\hat{J}(\vec{x})\ d^{3}x$

........(L.1.40b)

sehingga :

$$\bar{J}_o\bar{Q}_o = \sum_{\lambda=o,\pm 1} J_{\lambda}Q_{\lambda}^{*} = \sum_{\lambda=\pm 1} J_{\lambda}Q_{\lambda}^{*} + J_oQ_o$$

$$= \sum_{\lambda=\pm1} \mathcal{J}_\lambda Q_\lambda^* + \frac{\omega}{|\vec{q}|} \rho Q_o \quad \text{...(L.1.41)}$$

dengan $\mathcal{J}_o = \dfrac{\omega}{|\vec{q}|}\rho$, yang berasal dari kontinuitas arus inti.

Dengan substitusi persamaan (L.1.39) ke dalam persamaan (L.1.40) didapatkan :

$$m = \frac{1}{2J_i+1} \sum_{M_i}\sum_{M_f} \left[2\left\{ \sum_{\lambda=\pm1} \left(\mathcal{J}_\lambda Q_\lambda^* + \frac{\omega}{|\vec{q}|} - Q_o \right) \rho \right\} + 1/2q_\mu^2 \left\{ \sum_{\lambda=\pm1} \left(\mathcal{J}_\lambda \mathcal{J}_\lambda^* - \left(1 - \frac{\omega^2}{|\vec{q}|} \right) \rho\rho^* \right\} \right]$$

.........(L.1.42)

dengan bentuk :

$$\sum_{M_i}\sum_{M_f} \sum_{\lambda=\pm1} \mathcal{J}_\lambda \rho^* = \sum_{M_i}\sum_{M_f} \sum_{\lambda'=\pm1} \mathcal{J}_{\lambda'}^* \rho = 0$$

Karena arus transfersal membawa momentum sudut ±1 sepanjang $\vec{q}$ sementara arus longitudinal membawa momentum 0 sepanjang $\vec{q}$ sehingga keduanya tidak dapat berinterferensi dalam $\sum_{M_i} \sum_{M_f}$ karena keduanya memiliki state akhir yang berbeda. Oleh karena itu persamaan (L.1.42) menjadi :

$$m = \frac{1}{2J_i+1} \sum_{M_i}\sum_{M_f} \left[2\sum_{\lambda}\sum_{\lambda'} \left\{ \mathcal{J}_\lambda \mathcal{J}_\lambda * Q_\lambda Q_{\lambda'} * \left(\frac{\omega}{|\vec{q}|} - Q_o \right) \rho\rho* \right\} + \sum_{\lambda} 1/2q_\mu^2 \left\{ \left(\mathcal{J}_\lambda \mathcal{J}_\lambda^* - \left(1 - \frac{\omega^2}{|\vec{q}|} \right) \rho\rho* \right\} \right]$$

.......(L.1.43)

Dari transformasi Fourier :

$$\rho(\vec{q}) = \langle J_f M_f | \hat{\rho}(\vec{q}) | J_i M_i \rangle$$

$$= \int \exp(-i\vec{q}\cdot\vec{x}) \langle J_f M_f | \hat{\rho}(\vec{q}) | J_i M_i \rangle \, d^3x \quad \text{......(L.1.44)}$$

Jika $\exp(-i\vec{q}\cdot\vec{x})$ diekspansikan ke dalam gelombang sferik, akan mempunyai bentuk :

$$\exp(-i\vec{q}\cdot\vec{x}) = 4\pi \sum (-i)^{J} \int j_J(qx) Y_{JM}(\Omega_x) Y_{JM}^{*}(\Omega_q^{\sim})$$

$$\text{.......(L.1.45)}$$

sehinga persamaan (L.1.44) menjadi :

$$\rho(\vec{q}) = 4\pi \sum_{JM} (-i)^{J} \int j_J(qx) Y_{JM}(\Omega_x) Y_{JM}^{*}(\Omega_q^{\sim})$$

$$\times \langle J_f M_f | \hat{\rho}(\vec{q}) | J_i M_i \rangle \, d^3x$$

$$= 4\pi \sum_{JM} (-i)^{J} Y_{JM}^{*}(\Omega_q) \langle J_f M_f | M_{JM}^{coul} | J_i M_i \rangle \quad \text{..(L.1.46)}$$

didefinisikan M_{JM}^{coul} sebagai operator multipol Coulomb.

$$M_{JM}^{coul} \equiv \int j_J(qx) \; Y_{JM}(\Omega x) \hat{\rho}(\vec{x}) \; d^3x$$

Dengan menggunakan teorema Wigner-Eckart :

$$\langle J_f M_f | M_{JM}^{coul} | J_i M_i \rangle = (-1)^{J_f - M_f} \begin{pmatrix} J_f & J & J_i \\ -M_f & M & M_i \end{pmatrix} \langle J_f M_f \| M_{JM}^{coul} \| J_i M_i \rangle$$

$$\text{......(L.1.47)}$$

persamaan (L.1.46) menjadi :

$$\rho(\vec{q}) = 4\pi \sum_{JM} \Big\{ (-i)^{J} \; Y_{JM}^{*}(\Omega q)$$

$$(-1)^{J_f - M_f} \begin{pmatrix} J_f & J & J_i \\ -M_f & M & M_i \end{pmatrix} \langle J_f M_f \| M_{JM}^{coul} \| J_i M_i \rangle \Big\}$$

$$\text{.......(L.1.48)}$$

yang merupakan sumbangan untuk komponen ruang rapat arus. sehingga rerata yang melingkupi state awal dan jumlah yang melingkupi state akhir :

$$\frac{1}{2J_i+1}\sum_{M_i M_f}\sum \rho(\vec{q})\rho^*(\vec{q}) = \frac{(4\pi)^2}{2J_i+1}\sum_{M_i M_f}\sum (-1)^{J-J'} Y_{JM}^*(\Omega_q)$$

$$\times\ Y_{J'M'}(\Omega_q)\begin{pmatrix} J_f & J & J_i \\ -M_f & M & M_i \end{pmatrix}$$

$$\begin{pmatrix} J_f & J' & J_i \\ -M_f & M' & M_i \end{pmatrix} \langle J_f M_f \| M_{JM}^{coul} \| J_i M_i \rangle$$

$$\times\quad \langle J_f \| \hat{M}_{J'}^{coul}(q) \| J_i \rangle$$

.......(L.1.49)

Dari hubungan ortogonalitas :

$$\sum_{JM}\sum_{J'M'}\begin{pmatrix} J_f & J & J_i \\ -M_f & M & M_i \end{pmatrix}\begin{pmatrix} J_f & J' & J_i \\ -M_f & M' & M_i \end{pmatrix} = \frac{1}{2J+1}\,\delta_{JJ'}\delta_{MM'}$$

.......(L.1.50a)

teorema adisi Legendre :

$$\sum\sum Y_{JM}^*(\Omega_q)\,Y_{JM}(\Omega_q) = \frac{2J+1}{4\pi}$$ .....(L.1.50b)

maka persamaan (L.1.49) menjadi :

$$\frac{1}{2J_i+1}\sum_{M_i M_f}\sum \rho(\vec{q})\rho^*(\vec{q}) = \frac{4\pi}{2J+1}\sum_{J\leq 1}|\langle J_f \| \hat{M}_J^{coul}(q) \| J_i \rangle|^2$$

.......(L.1.51)

Dari definisi basis vektor bola persamaan (L.1.39) dan persamaan (L.1.40), elemen matrik operator rapat arus dapat dituliskan sebagai :

$$J_\lambda(\vec{q}) = \langle J_f M_f | \hat{J}_\lambda(\vec{q}) | J_i M_i \rangle$$

$$= \int \hat{e}_\lambda \exp(-i\vec{q}.\vec{x}) \langle J_f M_f | \vec{J}(x) | \hat{J}_i M_i \rangle \quad ......(L.1.52)$$

Faktor $\hat{e}_\lambda \exp(-i\vec{q}\cdot\vec{x})$ diekspansikan ke dalam gelombang bola dengan langkah-langkah sebagai berikut.

Dari definisi vektor harmonik bola :

$$Y^M_{Jl_1} \equiv \sum_m \sum_\lambda \langle lm1\lambda | l1JM \rangle \vec{Y}_{lm}(\Omega) \hat{1}_\lambda \quad ......(L.1.53)$$

$$\sum_J \sum_M \vec{Y}^M_{Jl_1} \langle lm'1\lambda' | l1JM \rangle = \sum_{JM} \sum_{m\lambda} \langle l\, m'1\lambda' | l1JM \rangle \langle lm1\lambda | l1JM \rangle Y_{lm}(\hat{\Omega}) e_\lambda$$

$$= \sum_m \sum_\lambda \delta_{mm'} Y_{lm}(\Omega) \hat{e}_\lambda$$

$$= Y_{lm'}(\Omega) \hat{e}_{\lambda'} \quad ......(L.1.54)$$

sehingga :

$$Y_{lm}(\Omega)\hat{e}_\lambda = \sum_J \sum_M \vec{Y}^M_{Jl_1} \langle lm1\lambda | l1JM \rangle \quad .....(L.1.55)$$

Jika $\vec{q}$ sejajar sumbu-z maka akan diperoleh :

$$\hat{e}_\lambda \exp(-i\vec{q}\cdot\vec{x}) = \sum_l (-1)^i \{4\pi(2l+1)\}^{1/2} jl(qx) Y_{l_0}(\Omega x) \hat{e}_\lambda$$

yang merupakan sumbangan untuk komponen ruang rapat arus.

Dari definisi basis vektor bola persamaan (L.1.39) dan persamaan (L.1.40), elemen matrik operator rapat arus dapat dituliskan sebagai :

$$J_\lambda(\vec{q}) = \langle J_f M_f | \hat{J}_\lambda(\vec{q}) | J_i M_i \rangle$$

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Faktor $\hat{e}_\lambda \exp(-i\vec{q}\cdot\vec{x})$ diekspansikan ke dalam gelombang bola dengan langkah-langkah sebagai berikut.

Dari definisi vektor harmonik bola :

$$Y^M_{Jl_1} \equiv \sum_m \sum_\lambda \langle lm1\lambda | l1JM \rangle \vec{Y}_{lm}(\Omega)\hat{1}_\lambda \quad \text{......(L.1.53)}$$

$$\sum_J \sum_M \vec{Y}^M_{Jl_1} \langle lm'1\lambda' | l1JM \rangle = \sum_{JM} \sum_{m\lambda} \langle l\, m'1\lambda' | l1JM \rangle$$

$$\langle lm1\lambda | l1JM \rangle Y_{lm}(\hat{\Omega}) e_\lambda$$

$$= \sum_m \sum_\lambda \delta_{mm'} Y_{lm}(\Omega)\hat{e}_\lambda$$

$$= Y_{lm'}(\Omega)\hat{e}_{\lambda'} \quad \text{......(L.1.54)}$$

sehingga :

$$Y_{lm}(\Omega)\hat{e}_\lambda = \sum_J \sum_M \vec{Y}^M_{Jl_1} \langle lm1\lambda | l1JM \rangle \quad \text{.....(L.1.55)}$$

Jika $\vec{q}$ sejajar sumbu-z maka akan diperoleh :

$$\hat{e}_\lambda \exp(-i\vec{q}\cdot\vec{x}) = \sum_l (-1)^1 \{4\pi(2l+1)\}^{1/2} jl(qx) Y_{l_0}(\Omega x)\hat{e}_\lambda$$

$$= \sum_{l} (-1)^{l} \{4\pi(2l+1)\}^{1/2} Jl(qx)$$

$$x <101\lambda|11J\lambda> \vec{Y}^{\lambda}_{Jl} \quad ....(L.1.56)$$

l dikopling dengan 1 dan J, sehingga l=J-1; J; J+1.

Sehingga :

$$\hat{e}_{\lambda} \exp(-i\vec{q}\cdot\vec{x}) = \sum_{J} (-1)^{J-1} \{4\pi(2l-1)^{1/2} j_{J-1}(qx)$$

$$x <J-i\ 01\lambda|J-1\ 1J\lambda> \vec{Y}^{\lambda}_{JJ-11}$$

$$= i\sum_{J} (-1)^{J} \{2\pi(2J+1)\}^{1/2} j_{J-1}(qx) \vec{Y}^{\lambda}_{JJ-11}$$

$$.....(L.1.57)$$

dengan

$$<J01\lambda|J1J\lambda> = \{ \frac{J}{2(2J+3)} \}^{1/2} \quad .....(L.1.58)$$

Sumbangan l = J pada penjumlahan ke 1 :

$$\hat{e}_{\lambda} \exp(-i\vec{q}\cdot\vec{x}) = \sum_{J} (-1)^{J} \{4\pi(2l+1)^{1/2} j_{J}(qx)$$

$$x <J\ 0\ 1\lambda|J\ 1\ J\lambda> \vec{Y}^{\lambda}_{JJ1}$$

$$= i\sum_{J} (-1)^{J} \{2\pi(2J+1)\}^{1/2} j_{J-1}(qx) \vec{Y}^{\lambda}_{JJ-11}$$

$$.....(L.1.59)$$

dengan :

$$<J\ 0\ 1\lambda|J\ 1\ J\lambda> = \lambda(1/2)^{1/2} \quad .....(L.1.60)$$

$$\hat{e}_{\lambda} \exp(-i\vec{q}\cdot\vec{x}) = \sum_{J} (-1)^{J-1} \{4\pi(2l-1)^{1/2} j_{J+1}(qx)$$

$$x \langle J+i\ 01\lambda | J+1\ 1J\lambda \rangle \vec{Y}^{\lambda}_{JJ+11}$$

$$= i\sum_{J} (-i)^{J} \{2\pi(2J+1)\}^{1/2} j_{J+1}(qx)\vec{Y}^{\lambda}_{JJ+11}$$

.....(L.1.61)

dengan :

$$\langle J\ 0\ 1\lambda | J\ 1\ J\lambda \rangle = \{\frac{J}{2(2J+3)}\}^{1/2} \qquad .....(L.1.62)$$

Dengan mengingat hubungan rekurensi (Lampiran-6), yang memberikan persamaan :

$$\frac{1}{q} \nabla_{x}(j_{J}(q_{x})Y_{JJ_{1}}) = -i(\frac{J}{2J+1})j_{J+1}(q_{x})\vec{Y}^{\lambda}_{JJ+11}$$

$$+ i(\frac{J+1}{2J+1})^{1/2} j_{J-1}(q_{x})\vec{Y}^{\lambda}_{JJ-11}$$

......(L.1.63)

maka sumbangan total l pada penjumlahan yang meliputi l adalah merupakan jumlah persamaan (L.1.57), (L.1.59) dan (L.1.61) pada penjumlahan tersebut, sehingga didapatkan hasil :

$$\hat{e}_{\lambda} \exp(-i\vec{q}\cdot\vec{x}) = -(2\pi)^{1/2} \sum_{J\leq 1} (-i)^{J}(2J+1)^{1/2}$$

$$\left\{ j_{J}(q_{x})\vec{Y}^{\lambda}_{JJ1} + \frac{1}{q}\nabla \times (j_{J}(q_{x})\vec{Y}^{\lambda}_{JJ1}) \right\}$$

.....(L.1.64)

sehingga persamaan (L.1.52) dapat dituliskan sebagai :

$$J(\vec{q}) = -(2\pi)^{1/2} \sum (-i)^{J}(2J+1)^{1/2}$$

$$<J_f M_f \| \lambda \hat{T}^{mag}_{JM}(q) + \hat{T}^{el}_{JM}(q) \| J_i M_i> \qquad \text{........(L.1.65)}$$

dengan definisi dari operator-operator multipol tranversal listrik dan operator-operator transfersal magnetik adalah sebagai berikut :

$$\hat{T}^{el.}_{J\lambda}(q) \equiv \frac{1}{q} \int \nabla x (j_J(q_x)\ \vec{Y}^{\lambda}_{JJ1})\ \hat{\vec{J}}(\vec{x})\ d^3x \qquad \text{....(L.1.66a)}$$

$$\hat{T}^{mag.}_{J\lambda}(q) \equiv \int j_J(q_x)\ \vec{Y}^{\lambda}_{JJ1} \cdot \hat{J}(\vec{x}) d^3x \qquad \text{....(L.1.67b)}$$

dan dalam koordinat sembarang, persamaan (L.1.65) harus diputar melalui sudut-sudut Euler dengan $\mathcal{D}^{J}_{M\lambda}(-\phi_q \theta_q \phi_q)$, maka :

$$\hat{T}^{el.}_{J\lambda}(q) = \sum_{M} \mathcal{D}^{J}_{M\lambda}(-\phi_q\ \theta_q\ \phi_q)\ \hat{T}^{el.}_{J\lambda}(q) \qquad \text{......(L.1.68a)}$$

$$\hat{T}^{mag.}_{J\lambda}(q) = \sum_{M} \mathcal{D}^{J}_{M\lambda}(-\phi_q\ \theta_q\ \phi_q)\ \hat{T}^{mag.}_{J\lambda}(q) \qquad \text{...(2.2.68b)}$$

Dengan menerapkan teorema Wigner-Eckart maka persamaan (L.1.65) menjadi :

$$\mathcal{J}_{\lambda}(\vec{q}) = -(2\pi)^{1/2} \sum_{J \geq 1} (-i)^J (2J+1)^{1/2} (-1)^{J_f - M_f} \sum_{M=-J}^{J} \begin{pmatrix} J_f & J & J_i \\ M_f & M & M_i \end{pmatrix}$$

$$\times <J_f M_f \| \lambda \hat{T}^{mag}_{JM}(q) + \hat{T}^{el}_{JM}(q) \| J_i M_i>$$

$$\mathcal{D}^{J}_{M\lambda}(-\phi_q\ \theta_q\ \phi_q) \qquad \text{....(L.1.69)}$$

Rerata yang meliputi state awal dan jumlahan yang meliputi state akhir, memberikan bentuk :

$$\frac{1}{2J_i+1}\sum_{M_i}\sum_{M_f} \mathcal{J}_\lambda(\vec{q})\mathcal{J}^*_{\lambda'}(\vec{q})$$

$$= \delta_{\lambda\lambda'} = \frac{2\pi}{2J_i+1}\sum_{JJ'MM'}(-1)^{J-J'}(2J'+1)$$

$$\times \begin{pmatrix} J_f & J & J_i \\ M_f & M & M_i \end{pmatrix} \langle J_f \| \lambda \hat{T}_J^{mag} + \hat{T}_J^{el}) \| J_i \rangle$$

$$\langle J_f \| \lambda \hat{T}_{J'}^{mag}(q) + \hat{T}_{J'}^{el}(q) \| J_i \rangle$$

$$\times \mathcal{D}^J_{M\lambda}(-\phi_q\ \theta_q\ \phi_q)\mathcal{D}^{J'}_{M'\lambda'}(-\phi_q\ \theta_q\ \phi_q)$$

$$= \delta_{\lambda\lambda'}\frac{2\pi}{2J_i+1}\sum_{J\geq 1}\{|\langle J_f \| \hat{T}_{J'}^{mag}(q) \| J_i \rangle|^2$$

$$+|\langle J_f \| \hat{T}_{J'}^{el}(q) \| J_i \rangle|^2\}$$

..........(L.1.70)

persamaan (L.1.70) tersebut dapat diperoleh dengan jalan :

$$\sum_{M_i}\sum_{M_f}\begin{pmatrix} J_f & J & J_i \\ M & M & M \end{pmatrix}\begin{pmatrix} J_f & J' & J_i \\ M & M'M & \end{pmatrix} = \frac{1}{2J+1}\delta_{JJ'}\delta_{MM'}$$

.....(L.1.71a)

$$\sum_{M_i}\sum_{m_f}\mathcal{D}^{-J}_{M\lambda}(-\phi_q\ \theta_q\ \phi_q)\mathcal{D}^{J'}_{M'\lambda'}(-\phi_q\ \theta_q\ \phi_q)^*\delta_{MM'} = \delta_{JJ'}\delta_{\lambda\lambda'}$$

......(L.1.71b)

kemudian disubstitusikan persamaan (L.1.70) dan (L.1.61) ke persamaan (L.1.49) serta penjabaran pada Lampiran-6, state akhir, memberikan bentuk :

$$\frac{1}{2Ji+1}\sum_{M_i}\sum_{M_f} \mathcal{J}_{\lambda}(\vec{q})\mathcal{J}^{*}_{\lambda'}(\vec{q})$$

$$= \delta_{\lambda\lambda'} = \frac{2\pi}{2J_i+1}\sum_{JJ'}\sum_{MM'}(-1)^{J-J'}(2J'+1)$$

$$\times \begin{pmatrix} J_f & J & J_i \\ M_f & M & M_i \end{pmatrix} \langle \mathcal{J}_f \| \lambda \hat{T}^{mag}_{J}(q) + \hat{T}^{el}_{J}(q) \| \mathcal{J}_i \rangle$$

$$\langle \mathcal{J}_f \| \lambda \hat{T}^{mag}_{J'}(q) + \hat{T}^{el}_{J'}(q) \| \mathcal{J}_i \rangle$$

$$\times \mathcal{D}^{J}_{M\lambda}(-\phi_q\ \theta_q\ \phi_q)\mathcal{D}^{J'}_{M'\lambda'}(-\phi_q\ \theta_q\ \phi_q)$$

$$= \delta_{\lambda\lambda'}\frac{2\pi}{2J_i+1}\sum_{J\geq 1}\{|\langle \mathcal{J}_f \| \hat{T}^{mag}_{J'}(q)\| \mathcal{J}_i\rangle|^2$$

$$+ |\langle \mathcal{J}_f \| \hat{T}^{el}_{J'}(q)\| \mathcal{J}_i\rangle|^2 \}$$

.........(L.1.70)

persamaan (L.1.70) tersebut dapat diperoleh dengan jalan :

$$\sum_{M_i}\sum_{M_f}\begin{pmatrix} J_f & J & J_i \\ M & M & M \end{pmatrix}\begin{pmatrix} J_f & J' & J_i \\ M & M'M & \end{pmatrix} = \frac{1}{2J+1}\delta_{JJ'}\delta_{MM'}$$

.....(L.1.71a)

$$\sum_{M_i}\sum_{m_f}\mathcal{D}^{J}_{M\lambda}(-\phi_q\ \theta_q\ \phi_q)\mathcal{D}^{J'}_{M'\lambda'}(-\phi_q\ \theta_q\ \phi_q)^{*}\delta_{MM'} = \delta_{JJ'}\delta_{\lambda\lambda'}$$

......(L.1.71b)

kemudian disubstitusikan persamaan (L.1.70) dan (L.1.61) ke persamaan (L.1.49) serta penjabaran pada Lampiran-6, sehingga diperoleh :

$$\frac{1}{2J_i+1}\sum_{M_i}\sum_{M_f}\left[2\sum_{\lambda}\sum_{\lambda'}\left\{\mathcal{J}_\lambda\mathcal{J}_{\lambda'}^{*}Q_\lambda Q_{\lambda'}^{*}+\left(\frac{\omega}{|\vec{q}|}-Q_o\right)^2\rho\rho^*\right\}\right.$$

$$\left.+\frac{1}{2}q_\mu^{2}\sum_{\lambda}\left\{\mathcal{J}_\lambda\mathcal{J}_\lambda^{*}-\left(1-\frac{\omega}{|\vec{q}|}\right)^2\rho\rho^*\right\}\right]$$

$$=\frac{4\pi}{2J_i+1}\left[\sum_{J\geq o}V_L(\theta)|<J_f\|\hat{M}_J^{coul}(q)\|J_i>|^2\right.$$

$$+\left\{\sum_{J\geq o}V_L(\theta)|<J_f\|\hat{T}_J^{mag}(q)\|J_i>|^2\right.$$

$$\left.\left.+|<J_f\|\hat{T}_J^{el}(q)\|J_i>|^2\right\}\right]$$

......(L.1.72)

V_L didefinisikan sebagai faktor kinetika longitudinal :

$$V_L(\theta)=\frac{q_\mu}{|\vec{q}|}\left(2Q_o^{2}-1/2|\vec{q}|\right)$$ .....(L.1.73a)

dan V_T didefinisikan sebagai faktor kinetika transfersal :

$$V_T(\theta)=(\vec{Q}^2-\left(\frac{q\cdot Q^2}{|\vec{q}|^2}+1/2q_\mu^{2}\right)$$ ...(L.1.73b)

Dari persamaan (L.1.72) tampang lintang hamburan dalam suku multipol dituliskan sebagai :

sehingga diperoleh :

$$\frac{1}{2J_i+1}\sum_{M_i}\sum_{M_f}\Big[\,2\sum_{\lambda}\sum_{\lambda'}\Big\{\mathcal{J}_\lambda \mathcal{J}_{\lambda'}^{*} Q_\lambda Q_{\lambda'}^{*} + \Big(\frac{\omega}{|\vec{q}|} - Q_o\Big)^2 \rho\rho^{*}\Big\}$$

$$+\ \frac{1}{2} q_\mu^{\,2} \sum_{\lambda}\Big\{\mathcal{J}_\lambda \mathcal{J}_\lambda^{*} - \Big(1-\frac{\omega}{|\vec{q}|}\Big)^2 \rho\rho^{*}\Big\}\Big]$$

$$= \frac{4\pi}{2J_i+1}\Big[\sum_{J\geq o} V_L(\theta)\,|\langle J_f \| \hat{M}_J^{coul}(q) \| J_i\rangle|^2$$

$$+\ \sum_{J\geq o} V_L(\theta)\,|\langle J_f \| \hat{T}_J^{mag}(q) \| J_i\rangle|^2$$

$$+\ |\langle J_f \| \hat{T}_J^{el}(q) \| J_i\rangle|^2 \,\}\Big] \qquad \text{......(L.1.72)}$$

V_L didefinisikan sebagai faktor kinetika longitudinal :

$$V_L(\theta) = \frac{q_\mu}{|\vec{q}|}\,(2Q_o^{\,2} - 1/2|\vec{q}|) \qquad \text{.....(L.1.73a)}$$

dan V_T didefinisikan sebagai faktor kinetika transfersal :

$$V_T(\theta) = (\vec{Q}^2 - (\frac{q \cdot Q^2}{|\vec{q}|^2} + 1/2 q_\mu^{\,2}) \qquad \text{...(L.1.73b)}$$

Dari persamaan (L.1.72) tampang lintang hamburan dalam suku multipol dituliskan sebagai :

$$\left(\frac{d\sigma}{d\Omega} \right) = \frac{q\alpha^2}{q_\mu^{\ 4}} \frac{\epsilon'}{\epsilon} \frac{4\pi}{2J_i+1} \left[\sum_{J\geq 0} V_L(\theta) |<J_f \| \hat{M}_J^{coul}(q) \| J_i>|^2 \right.$$

$$+ \sum_{J\geq 0} \left\{ V_T(\theta) |<J_f \| \hat{T}_J^{mag}(q) \| J_i>|^2 \right.$$

$$\left. \left. + |<J_f \| \hat{T}_J^{mag}(q) \| J_i>|^2 \right\} \right]$$

......(L.1.74)

Dari pendekatan relativitas, m ≈ 0 didapatkan :

$$V_L(\theta) = \frac{q_\mu^{\ 4}}{|\vec{q}|^4} (2Q_o^{\ 2} - 1/2|\vec{q}|^2) = \frac{q_\mu^{\ 4}}{|\vec{q}|^4} \cdot \{(\epsilon'+\epsilon)^2 - \vec{k}' - \vec{k})^2\}$$

$$= 2\epsilon\epsilon' \cos^2 \frac{\theta}{2}$$

.........(L.1.75a)

$$V_T(\theta) = (\vec{Q}^2 - (\frac{q \cdot Q^2}{|\vec{q}|^2} + 1/2q_\mu^{\ 2})$$

$$= 1/4(\vec{k}+\vec{k})^2 - \frac{(\vec{k}'-\vec{k})^2 \cdot (\vec{k}'-\vec{k})^2}{|\vec{k}'-\vec{k}|^2} + 1/2(k'-k)^2$$

$$\approx 4\epsilon\epsilon' \sin^2 \frac{\theta}{2} + 2\epsilon\epsilon \cos^2 \frac{\theta}{2}$$ .....(L.1.75b)

sehingga diperoleh hasil persamaan tampang lintang term multipol :

$$\left(\frac{d\sigma}{d\Omega}\right)_{ifi} = \frac{4\pi}{1+(2\epsilon\ \sin^2\frac{\theta}{2}/M)}$$

$$\frac{1}{2J_i+1}\left[\sum_{J\geq 0}|<J_f\|\ \hat{M}_J^{coul}(q)\|J_i>|^2\right.$$

$$+\ (1/2+\tan^2\frac{\theta}{2})\sum_{J\geq 1}\left\{|<J_f\|\ \hat{T}_J^{mag}\ (q)\|J_i>|^2\right.$$

$$\left.\left.+\ |<J_f\|\ \hat{T}_J^{el}(q)\|J_i>|^2\right\}\right] \qquad .....(L.1.76)$$

LAMPIRAN-2

PENJABARAN BENTUK EKSPLISIT

PERSAMAAN FAKTOR BENTUK MUATAN INTI

Dengan menggunakan definisi operator multipol Coulomb pada Lampiran-1 fungsi harmonik bola berbentuk :

$$Y_{JM}(\theta,\emptyset) = (-1)^{1/2(M+|M|)}\left\{\frac{2J+1}{4\pi}\;\frac{(J-|M|)!}{(J+|M|)!}\right\}^{1/2}\sin^{|M|}\theta$$

$$\times\;\frac{1}{J^J J!}\left(\frac{d}{d\cos\theta}\right)^{J+|M|}(\cos^2\theta-1)^J\exp(iM\emptyset)\quad\ldots.(L.2.1)$$

maka paritasnya dapat dicari dengan transformasi pencerminan persamaan (L.2.1) terhadap titik acuan sebagai berikut :

$$Y_{JM}(\pi-\theta,\emptyset+\pi)$$

$$= (-1)^{1/2(M+|M|)}\left\{\frac{2J+1}{4\pi}\;\frac{(J-|M|)!}{(J+|M|)!}\right\}^{1/2}\sin^{|M|}(\pi-\theta)$$

$$\times\;\frac{1}{J^J J!}\left(\frac{d}{d\cos(\pi-\theta)}\right)^{J+|M|}(\cos^2(\pi-\theta)-1)^J e^{iM(\emptyset+m)}$$

$$= (-1)^J(-1)^{1/2}(M+|M|)\left\{\frac{2J+1}{4\pi}\;\frac{(J-|M|)!}{(J+|M|)!}\right\}^{1/2}\sin^{|M|}\theta$$

$$\frac{1}{J^J J!}\left(\frac{d}{d\cos\theta}\right)^{J+|M|}\times\;(\cos^2\theta-1)^j e^{iM\theta}$$

$$= (-1)^J Y_{JM}(\theta,\emptyset)\qquad\ldots\ldots(L.2.2)$$

persamaan paritas untuk $Y_{JM}(\theta,\emptyset)$ dapat dituliskan sebagai:

$$\hat{\Pi}\ Y_{JM}(\theta,\emptyset)\hat{\Pi}^{-1} = (-1)^{J} Y_{JM}(\theta,\emptyset) \qquad .....(L.2.3)$$

maka untuk operator multipol coulomb, persamaan paritasnya adalah :

$$\Pi\ \hat{M}_{J}^{coul}\hat{\Pi}^{-1} = (-1)^{J} M_{J}^{coul}(q) \qquad ......(L.2.4)$$

Karena operator coulomb mempunyai paritas bernilai $(-1)^{J}$,maka integrasi pada persamaan (L.1.74) adalah hanya berlaku untuk fungsi-fungsi genap sehingga hanya J genap yang dapat menyumbang pada hamburan , yakni : C0, C2, C4, dan seterusnya.

Persamaan (L.2.1) dapat menjadi sederhana karena untuk J=0 (suku pertama momen monopol magnetik) terdapat sumbangan yang memenuhi persyratan penjumlahan momentum sudut, sehingga diperoleh bentuk persamaan :

$$\left(\frac{d\sigma}{d\Omega}\right)_{e\ell} = \frac{z^{2}\sigma_{M}\ |F_{L}(q)|^{2}}{1+(2\epsilon\ \sin^{2} 1/2\theta/M)} \qquad ....(L.2.5)$$

dengan faktor bentuk muatan C0 untuk distribusi muatan dasar berbentuk :

$$|fo(q)| = \frac{\sqrt{4\pi}}{z} <0\|\hat{M}_{J}^{coul}(q)\|0> \qquad ....(L.2.6)$$

suku pertama persamaan (L.2.74) dapat ditulikan sebagai :

$$<0\|\hat{M}_{0_{0}}^{coul}(q)\|0> = (-1)^{0}\begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}<0\|\hat{M}_{0}^{coul}(q)\|0>$$

atau :

$$<0\|\hat{M}_0^{coul}(q)\|0> = <0|\hat{M}_{0_0}^{coul}(q)|0>$$

$$\hat{M}_0^{coul}(q) = \int_0^{\infty} j_o(q_x)\ Y_{oo}(\theta,\phi)\rho(x)\ d^3x$$

$$= \int_0^{\infty} \frac{\sin qr}{qr} \frac{1}{\sqrt{4\pi}} \rho(r)\ d^3r$$

$$= \sqrt{4\pi} \int_0^{\infty} r\ \sin qr\ \rho(r)\ dr \qquad \text{......(L.2.7)}$$

sehingga persamaan (L.2.6) menjadi :

$$|Fo(q)| = \frac{4\pi}{zq} \int_0^{\infty} r\ \sin qr\ \rho(r)\ dr \qquad \text{.....(L.2.8)}$$

LAMPIRAN-3

PENURUNAN FAKTOR BENTUK ELASTIK MUATAN KEADAAN DASAR

$$F_o(q) = \frac{4\pi\rho}{zq} \int_o^{\infty} (1 + \exp((r-R)/a))^{-1} r \sin qr \, dr$$

$$= \int_o^{R} (1 + \exp((r-R)/a))^{-1} r \sin qr \, dr$$

$$+ \int_R^{\infty} (1 + \exp((r-R)/a))^{-1} r \sin qr \, dr$$

...(L.3.1)

Dengan memakai ekspansi $(1+\delta)^{-1} = \sum_{n=o}^{\infty} (-1)^{-1}\delta^{n}$; $|\delta|>1$

dan dengan memisalkan kedua suku tersebut sebagai suku A dan B sehingga $F_o(q) = A + B$, maka persamaan diatas dapat dihitung sebagai berikut :

Perhitungan untuk suku pertama persamaan (L.3.2) :

$$A = \int_R^{\infty} (1 + \exp((r-R)/a))^{-1} r \sin qr \, dr$$

$$= \sum_{n=o}^{\infty} (-1)^{n} \exp(-nR/a) \int_o^{\infty} \exp(nr/a) \, r \sin qr \, dr \quad ...(L.3.2)$$

Ditinjau bentuk integral :

$$\sum_{n=o}^{\infty} (-1)^{n} \int_o^{R} \exp(nr/a) r \sin qr \, dr$$

$$= \sum_{n=o}^{\infty} (-1)^{n} \, \mathrm{Im} \int_o^{R} \exp(nr/a + iq) r \, dr$$

$$= \sum_{n=0}^{\infty} (-1)^n \left\{ \frac{-q \cos R \exp(nR/a) + (n/a)\sin qr \exp(nR/a) + q}{(n/a)^2 + q^2} \right\}$$

sehingga :

$$\sum_{n=0}^{\infty} (-1)^n \int_0^R \exp(n(r-R/a) \sin qr \, dr$$

$$= \sum_{n=0}^{\infty} \frac{(-1)^n -q \cos qr + (n/a)\sin qR + q \exp(1-nR/a)}{(n/a)^2 + q^2}$$

....(L.3.3)

Derivatif persamaan (L.3.3) terhadap (n/a) :

$$\sum_{n=0}^{\infty} (-1)^n \int_0^R (r-R) \exp(n(r-R/a)\sin qr \, dr$$

$$= \{(q^2-(n/a)^2 \sin qR + 2q(n/a) \cos qR$$

$$- (qR(n/a)^2 + q^3R + 2q(n/a)) \exp(-nR/a)\}$$

sehingga :

$$\sum_{n=0}^{\infty} (-1)^n \int_0^R r \exp(n(r-R/a)\sin qr \, dr$$

$$= \sum_{n=0}^{\infty} \frac{(-1)^n}{((n/a)^2 + q^2)^2} [\{q^2-(n/a)^2 + R(n/a)^3$$

$$+ q^2R(n/a)\}\sin qr$$

$$+ \{2q(n/a)$$

$$- qR(n/a)^2 - q^3R\}\cos qR$$

$$- 2q(n/a) \exp(-nR/a)] \quad ...(L.3.4)$$

Dengan substitusi $r = R/a$ dan $Q = qR$, maka persamaan (L.3.4) menjadi :

$$A = \sum_{n=0}^{\infty} \frac{R^2 (-1)^n}{((n/a)^2 + q^2)^2} [\{Q^2 - (nr)^3 + (nr)^3 + Q^2(nr)\}\sin Q + \{2Q(nr) - Q(nr)^2 - Q^3\}\cos Q - 2Q(nr)\exp(-nr)]$$

$$= (R/Q)^2(\sin Q - Q\cos Q) + \sum_{n=0}^{\infty} \frac{R^2 (-1)^n}{((n/a)^2 + q^2)^2} [\{Q^2 - (nr)^3 + (nr)^3 + Q^2(nr)\}\sin Q + \{2Q(nr) - Q(nr)^2 - Q^3\}\cos Q - 2Q(nr)\exp(-nr)] \quad \text{....(L.3.5)}$$

Perhitungan suku ke dua persamaan (L.3.5) :

$$B = \int_R^{\infty} (\exp(r-R)/a)^{-1}(1 + \exp(-(r-R)/a)^{-1} r \sin qr\, dr$$

$$= \sum_{n=0}^{\infty} (-1)^n \int_R^{\infty} \exp(-(-n+1)(r-R)/a) r \sin qr\, dr$$

$$= -\sum_{n=1}^{\infty} (-1)^n \int_R^{\infty} \exp(-n(r-R)/a) r \sin qr\, dr \quad \text{...(L.3.6)}$$

Tinjau bentuk integral :

$$\sum_{n=1} (-1) \int_R^{\infty} \exp(-nr/a) \sin qr\, dr$$

$$= \sum_{n=1}^{\infty} (-1)^n \text{ Im} \int_R^{\infty} \exp((-n/a+iq)r)dr$$

$$= \sum_{n=1}^{\infty} \frac{(-1)^n \exp(-nR/a)}{(n/a)^2+q^2} \{q \cos qR + (n/a)\sin qR\}$$

sehingga :

$$\sum_{n=1}^{\infty} (-1)^n \int_R^{\infty} \exp(-nr/a) \sin qr \, dr$$

$$= \sum_{n=1}^{\infty} \frac{(-1)^n}{(n/a)^2+ q^2}\{q \cos qR + (n/a) \sin qR \}$$

Derivatif persamaan (L.3.7) terhadap (n/a) menhasilkan :

$$\sum_{n=1}^{\infty} (-1)^n \int_R^{\infty} (R-r)\exp(-n(r-R/a) \sin qr \, dr$$

$$= \sum_{n=1}^{\infty} \frac{(-1)^n}{(n/a)^2+ q^2}\{q^2- (n/a)^2\sin qR - 2q(n/a)\cos qR \}$$

sehingga :

$$B = -\sum_{n=1}^{\infty} \frac{(-1)^n}{((n/a)^2+ q)^2} [\{R(n/a)^3+ q^2R(n/a) + (n/a)^2- q^2\}\sin qR + \{qR(n/a)^2+ q^3R + 2q(n/a)\}\cos qR] \quad \text{....(L.3.8)}$$

Substitusi r = R/a dan Q = qR, maka persamaan (L.3.8) menajadi :

$$B = -\sum_{n=1}^{\infty} \frac{R^3\ (-1)^n}{((n/a)^2 + q^2)^2} [\{(n/a)^3 + Q^2 R(n/a) + (n/a)^2 - Q^2\} \sin QR + \{Q(n/a)^2 + Q^3 R + 2q(n/a)\} \cos Q]$$

....(L.3.9)

Substitusi persamaan (L.3.9), dan (L.3.5) ke dalam persamaan (L.3.1), diperoleh :

$$3z/4\pi R^3 \rho_o\ F_o(q) = (3/Q^3)(\sin Q - Q\cos Q) - (6/Q)\sum_{n=0}^{\infty} (-1)^n \left\{ \frac{Q\cos Q}{((nr)^2 + Q^2)^2} + ((nr)^2 - Q^2)\sin Q + \frac{Q(nr)\exp(-nr)}{((nr)^2 + Q^2)^2} \right\}$$

....(L.3.10)

Faktor z dapat dicari dari normalisasi :

$$z = 4\pi \int_0^{\infty} \rho(r) x^2\ dx = 4\pi\rho_o \int_0^{\infty} r^2 (1 + \exp((r-R)/a))^{-1}\ dr$$

....(L.3.11)

Analog dengan cara mendapatkan persamaan (10.11). Sehingga :

$$z = 4\pi R^3 \rho_o \{1/3 - 4 \sum_{n=1}^{\infty} \frac{(-1)^n}{(nr)^2} - 2 \sum_{n=1}^{\infty} \frac{(-1)^n \exp(-nr)}{(nr)^3} \}$$

sehingga :

$$(3z/4\pi R^3 \rho_o) = 1 - 12 \sum_{n=1}^{\infty} \frac{(-1)^n}{(nr)^2} - 6 \sum_{n=1}^{\infty} \frac{(-1)^n \exp(-nr)}{(nr)^3}$$

maka sebagai hasil akhir persamaan faktor bentuk menjadi :

$$F_o(q) = \frac{3/Q^3(\sin Q - Q\cos Q) - 6/Q \sum_{n=1}^{\infty} (-1)^n \left\{ \frac{Q\cos Q}{(nr)^2+Q^2} + ((nr)^2-Q)^2 \sin Q + \frac{Q\, nr \exp(-nr)}{(nr)^2+Q^2} \right\}}{1 - 12 \sum_{n=1}^{\infty} \frac{(-1)^n}{(nr)^2} - 6 \sum_{n=1}^{\infty} \frac{(-1)^n \exp(-nr)}{(nr)^3}} \qquad \text{....(L.3.12)}$$

Dari tabel integral (Gratstin dan Rizyc) diperoleh :

$$\sum_{n=1}^{\infty} (-1)^n (nr)^{-2} = -(\pi/r)^2/12 \qquad \text{....(L.3.13)}$$

$$\sum_{n=1}^{\infty} (-1)^n ((nr)^2+Q^2)^{-1} = (1/2Q^2)(T \sinh T - 1) \qquad \text{..(L.3.14)}$$

$$\sum_{n=1}^{\infty} (-1)^n ((nr)^2+Q^2)^{-2} = \frac{T \sinh T - 2\sinh^2 T + T^2 \cosh T}{4Q^4 \sinh^2 T} \qquad \text{...(L.3.15)}$$

dengan :

$T = \pi Q/r$

maka persamaan (L.3.12) menjadi :

$$F_o(q) = \frac{\{3/}{}$$

$$F_o(q) = \frac{3/Q^3(\sin Q - Q\cos Q) - 6/Q \sum_{n=1}^{\infty} (-1)^n \left\{ \frac{Q\cos Q}{(nr)^2+Q^2} + ((nr)^2-Q)^2 \sin Q + \frac{Q\, nr \exp(-nr)}{(nr)^2+Q^2} \right\}}{1 - 12 \sum_{n=1}^{\infty} \frac{(-1)^n}{(nr)^2} - 6 \sum_{n=1}^{\infty} \frac{(-1)^n \exp(-nr)}{(nr)^3}}$$

....(L.3.12)

Dari tabel integral (Gratstin dan Rizyc) diperoleh :

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$$\sum_{n=1}^{\infty} (-1)^n ((nr)^2+Q^2)^{-2} = \frac{T \sinh T - 2\sinh^2 T + T^2 \cosh T}{4Q^4 \sinh^2 T}$$

...(L.3.15)

dengan :

$T = \pi Q/r$

maka persamaan (L.3.12) menjadi :

LAMPIRAN-4
FAKTOR BENTUK LEPTON

$$\sum_{\lambda}\sum_{\lambda'} |\ \bar{U}_{\lambda'}(\vec{k}')\ \gamma_{\mu}\ U_{\lambda}(\vec{k})^{2}\ |^{2} = \sum_{\lambda}\sum_{\lambda'}\{\ \bar{U}_{\lambda'}(\vec{k}')\ \gamma_{\mu}\ U_{\lambda}(\vec{k})\}$$

$$\{\ \bar{U}_{\lambda'}(\vec{k}')\ \gamma_{\nu}\ U_{\lambda}(\vec{k})\}^{*}$$

$$= \sum_{\lambda}\sum_{\lambda'}\{\ \bar{U}_{\lambda'}(\vec{k}')\ \gamma_{\mu}\ U_{\lambda}(\vec{k})\}$$

$$\{\ \bar{U}_{\lambda'}(\vec{k}')^{+}\gamma_{\nu}\ U_{\lambda}(\vec{k})\}^{*}$$

$$= \sum_{\lambda}\sum_{\lambda'}\{\ \bar{U}_{\lambda'}(\vec{k}')\ \gamma_{\mu}\ U_{\lambda}(\vec{k})\}$$

$$\{\ \bar{U}_{\lambda}\ (\vec{k}')^{+}\gamma_{\nu}\ U_{\lambda'}(\vec{k}')^{*}\}$$

$$= \sum_{\lambda}\sum_{\lambda'}\{\ \bar{U}_{\lambda'}(\vec{k}')\}_{\delta}\{\gamma_{\mu}\}_{\delta\gamma}$$

$$\{\bar{U}_{\lambda}(\vec{k})\bar{U}_{\lambda}(\vec{k})\}_{\gamma\rho}\{\gamma_{\nu}\}_{\beta\alpha}\{U_{\lambda'}(\vec{k}')\}_{\alpha}$$

$$= \sum_{\lambda}\sum_{\lambda'}\sum_{\alpha}\sum_{\beta}\sum_{\gamma}\sum_{\delta}\{\gamma_{\nu}\}_{\delta\gamma}$$

$$\{\bar{U}_{\lambda}(\vec{k})\bar{U}_{\lambda}(\vec{k})\}_{\gamma\rho}$$

$$\{\gamma_{\nu}\}_{\beta\alpha}$$

$$\{\bar{U}_{\lambda'}(\vec{k}')\bar{U}_{\lambda'}(\vec{k}')_{\alpha\delta}\} \qquad \text{.....(L.4.1)}$$

Dari sifat orthogonalitas spinor Dirac :

$$\bar{U}_{\lambda'}(\vec{k}')\ \bar{U}_{\lambda}(\vec{k}) = \delta_{\lambda\lambda'}\ ;\quad \bar{U}_{\lambda}(\vec{k})\ \bar{V}_{\lambda}(\vec{k}) = \bar{U}_{\lambda}(\vec{k})\ \bar{V}_{\lambda}(\vec{k}) = 0 \qquad \text{.....(L.4.2a)}$$

$$\bar{V}_{\lambda'}(\vec{k})\ \bar{V}_{\lambda}(\vec{k}) = \delta_{\lambda\lambda'} \quad ; \quad \bar{V}_{\lambda}(\vec{k})\ \bar{U}_{\lambda}(\vec{k}) = \bar{V}_{\lambda}(\vec{k})\ \bar{U}_{\lambda}(\vec{k}) = 0 \qquad \text{.....(L.4.2b)}$$

dengan syarat kelengkapannya :

$$W = \sum_{\lambda} (a_{\lambda}\ U_{\lambda}(\vec{k}) + b_{\lambda}\ V_{\lambda}(\vec{k})) \qquad \text{.....(L.4.2c)}$$

Jika persamaan (L.4.2b) dikenai berturut-turut dengan $\bar{U}_{\lambda}(\vec{k})$ dari kanan dan kiri, maka diperoleh :

$$a_{\lambda} = \bar{U}_{\lambda}(\vec{k})W \quad \text{dan} \quad b_{\lambda} = \bar{V}_{\lambda}(\vec{k})W \qquad \text{...(L.4.2d)}$$

sehingga didapatkan bentuk :

$$\sum_{\lambda} \{\ U_{\lambda}(\vec{k})\ \bar{U}_{\lambda}(\vec{k}) + V_{\lambda}(\vec{k})\ \bar{V}_{\lambda}(\vec{k})\ \} = 1 \qquad \text{..(L.4.3)}$$

Persaman Dirac untik spinor elektron dan positron :

$$(i\gamma \cdot k + m)\ U_{\lambda}(\vec{k}) = 0 \quad \text{dan} \quad (-i\gamma \cdot k + m)\ V_{\lambda}(\vec{k}) = 0 \qquad \text{....(L.4.4)}$$

dengan dibawa ke bentuk :

$$\frac{-\ i\gamma \cdot k + m}{2m}\ U_{\lambda}(\vec{k}) = U_{\lambda}(\vec{k})$$

dan :

$$\frac{-\ i\gamma \cdot k + m}{2m}\ V_{\lambda}(\vec{k}) = V_{\lambda}(\vec{k}) \qquad \text{.....(L.4.5)}$$

Sehingga dapat didefinikan operator proyeksi kafimir :

$$\Lambda_{\pm} = \pm\ \frac{-\ i\gamma \cdot k + m}{2m} \qquad \text{....(L.4.6)}$$

dengan :

$$\Lambda_{+}\ U_{\lambda}(\vec{k}) = U_{\lambda}(\vec{k}) \qquad \text{.....(L.4.7a)}$$

$$\wedge_+ V_\lambda(\vec{k}) = \wedge_- U_\lambda(\vec{k}) = 0 \quad .....(L.4.7b)$$

$$\wedge_- V_\lambda(\vec{k}) = V_\lambda(\vec{k}) \quad .....(L.4.7c)$$

Pada persaman (L.4.3), jika dikenai $\wedge_\pm$ dari kanan dan kiri diperoleh bentuk :

$$\wedge_\pm \sum_\lambda \{ U_\lambda(\vec{k})\, \bar{U}_\lambda(\vec{k}) + V_\lambda(\vec{k})\, \bar{V}_\lambda(\vec{k}) \}$$

$$= \sum_\lambda \wedge_\pm \{ U_\lambda(\vec{k})\, \bar{U}_\lambda(\vec{k}) + \sum_\lambda \wedge_\pm V_\lambda(\vec{k})\, \bar{V}_\lambda(\vec{k}) \} = \wedge_\pm$$

$$...(L.4.8)$$

dengan mengingat persamaan (L.4.7) akan memberikan :

$$\sum_\lambda U_\lambda(\vec{k})\, \bar{U}_\lambda(\vec{k}) = \wedge_+ \quad ....(L.4.9a)$$

$$\sum_\lambda V_\lambda(\vec{k})\, \bar{V}_\lambda(\vec{k}) = \wedge_- \quad ....(L.4.9b)$$

Substitusi persamaan (L.4.9a) untuk elektron ke dalam persamaan (L.4.1) diperoleh :

$$\sum_\lambda \sum_{\lambda'} | \bar{U}_\lambda(\vec{k})\, \gamma_\mu\, \bar{U}(\vec{k}) |^2$$

$$= \sum_\lambda \sum_{\lambda'} \sum_\alpha \sum_\beta \sum_\gamma \sum_\delta \{\gamma_\mu\}_{\delta\gamma} \{U_\lambda(\vec{k})\, \bar{U}_\lambda(\vec{k})_{\gamma\beta}\} \{\gamma_\nu\}_{\beta\alpha} \{U_{\lambda'}(\vec{k})\, \bar{U}_{\lambda'}(\vec{k})\}$$

$$= \frac{1}{4m^2}\, Tr\, \{\gamma_\mu(-i\gamma\, k+m)\, \gamma_\mu\, (-i\gamma \cdot k'+m)\} \quad ....(L.4.10)$$

Dari definisi persamaan (L.1.55) dapat dijabarkan langkah-langkah sebagai berikut :

$$-\eta_{\mu\nu} = 1/2\, Tr\{\gamma_\mu(-i\gamma \cdot k+m)\, \gamma_\mu\, (-i\gamma \cdot k'+m)\}$$

$$= 1/2\ Tr(\gamma_{\mu m}(-i\gamma_{\mu}\gamma_{\rho}K_{\rho})(\gamma_{\nu m}-i\gamma_{\nu}\gamma_{\sigma}K'_{\sigma})$$

$$= 1/2\ \{Tr(\gamma_{\mu}\gamma_{\nu})-k_{\rho}k'_{\sigma}\ Tr(\gamma_{\mu}\gamma_{\rho}\gamma_{\nu}\gamma_{\sigma})\} \quad ....(L.4.11)$$

dengan :

$$Tr(\gamma_{\mu}\gamma_{\nu}\gamma_{\sigma}) = Tr(\gamma_{\mu}\gamma_{\rho}\gamma_{\nu}) = 0 \quad ...(L.4.12)$$

Term pertama persamaan (L.4.11) memberikan :

$$Tr(\gamma_{\mu}\gamma_{\nu}) = Tr(\gamma_{\nu}\gamma_{\mu}) = 1/2\ Tr(\gamma_{\mu}\gamma_{\nu} + \gamma_{\nu}\gamma_{\mu}) = 4\delta_{\mu\nu}$$

...(L.4.13)

Term kedua persamaan (L.4.11) memberikan :

$$Tr(\gamma_{\mu}\gamma_{\rho}\gamma_{\nu}\gamma_{\sigma}) = Tr(\gamma_{\sigma}\gamma_{\mu}\gamma_{\rho}\gamma_{\nu}) = Tr(2\delta_{\mu\nu}-\gamma_{\mu}\gamma_{\sigma})_{\gamma\rho\gamma\sigma}$$

$$= 2\delta_{\mu\sigma}\ Tr(\gamma_{\rho}\gamma_{\gamma})-Tr\ \gamma_{\mu}(\gamma_{\sigma}\gamma_{\rho})_{\gamma\nu}$$

$$= 8\delta_{\mu\sigma}\delta_{\rho\nu}-Tr\ \gamma_{\mu}(2\delta_{\sigma\rho}-\gamma_{\rho}\gamma_{\sigma})_{\gamma\nu}$$

$$= 8\ \delta_{\mu\sigma}\delta_{\rho\nu} - 8\delta_{\sigma\rho}\delta_{\mu\nu} + Tr\ \gamma_{\mu}\gamma_{\rho}(2\delta_{\sigma\nu}-\gamma_{\nu}\gamma_{\sigma})$$

$$= 8\ \delta_{\mu\sigma}\delta_{\rho\nu} - 8\delta_{\sigma\rho}\delta_{\mu\nu} + 8\delta_{\sigma\nu}\delta_{\mu\rho}-Tr(\gamma_{\mu}\gamma_{\rho}\gamma_{\nu}\gamma_{\sigma})$$

sehingga didapatkan :

$$Tr(\gamma_{\mu}\gamma_{\rho}\gamma_{\nu}\gamma_{\sigma}) = 4(\delta_{\mu\sigma}\delta_{\rho\nu}-\delta_{\sigma\rho}\delta_{\mu\nu}+\delta_{\sigma\nu}\delta_{\mu\rho}) \quad ..(L.4.14)$$

atau :

$$k_{\rho}k_{\sigma}'T_{r}(\gamma_{\mu}\gamma_{\rho}\gamma_{\nu}\gamma_{\sigma}) = 4(k_{\mu}k_{\nu'}+ k_{\nu}k_{\mu'}-k\cdot k'\delta_{\mu\nu})$$

...(L.4.15)

substitusi persamaan (L.4.15) dan persamaan (L.4.13) ke dalam persamaan (L.4.11) :

$$-\eta_{\mu\nu} = 1/2(4m^2\delta_{\mu\nu} - 4(k_\mu k_\nu' + k_\nu k_\mu' + k\cdot k'\delta_{\mu\nu})$$

$$= 2\{(m^2 + k\cdot k')\delta_{\mu\nu} - (k_\mu k_\nu' + k_\nu k_\mu')\}$$

...(L.4.16)

Dengan mengingat :

$$q_\mu^2 = (k'-k)_\mu^2 = (k')^2 + (k)^2 - 2k\cdot k' = (-2m^2) - 2k\cdot k'$$

atau :

$$(m^2 + k\cdot k') = -1/2 q_\mu^2 \qquad ...(L.4.17)$$

maka hasil akhirnya adalah :

$$\eta_{\mu\nu} = -1/2\, T_r\{\gamma_\mu(-i\gamma\cdot k + m)\, \gamma_\nu\, (-i\gamma\cdot k' + m)\}$$

$$= 2(k_\mu k_\nu' + k_\nu k_\mu' + 1/2 q_\mu^2 \delta_{\mu\nu}) \qquad ....(L.4.18)$$

LAMPIRAN-5

PERKALIAN FAKTOR BENTUK LEPTON DAN HADRON

$$\eta_{\mu\nu}W_{\mu\nu} = 2(k_\mu k_\nu{}' + k_\nu k_\mu{}' + 1/2q_\mu{}^2\delta_{\mu\nu})\left\{\left(\delta_{\mu\nu} - \frac{q_\mu q_\nu}{q_\mu{}^2}\right)W_1\right.$$

$$\left. + \left(P_\mu - \frac{q\cdot P}{q_\mu{}^2}q_\mu\right)\left(P_\nu - \frac{q\cdot P}{q_\mu{}^2}q_\mu\right)\frac{W_2}{M^2}\right\}$$

$$= 2(k_\mu k_\nu{}' + k_\nu k_\mu{}' + 1/2q_\mu{}^2\delta_{\mu\nu})\left(\delta_{\mu\nu} - \frac{q_\mu q_\nu}{q_\mu{}^2}\right)W_1$$

$$+ \left\{2\left(k_\mu k_\nu{}' + k_\nu k_\mu{}' + 1/2q_\mu{}^2\delta_{\mu\nu}\right)\left(P_\mu - \frac{q.P}{q_\mu{}^2}q_\mu\right)\right.$$

$$\left. x\left(P_\nu - \frac{q.P}{q_\mu{}^2}q_\mu\right)\frac{W_2}{M^2}\right\}$$

$$= GW_1 + H\frac{W_2}{M^2} \qquad \ldots.(L.5.1)$$

Koefisien suku pertama persamaan (L.5.1) memberikan :

$$G = 2(k_\mu k_\nu{}' + k_\nu k_\mu{}' + 1/2q_\mu{}^2\delta_{\mu\nu})\left(\delta_{\mu\nu} - \frac{q_\mu q_\nu}{q_\mu{}^2}\right)$$

$$= 2\left[k_\mu k_\nu{}'\delta_{\mu\nu} + k_\nu k_\mu{}'\delta_{\mu\nu} + 1/2q_\mu^2\,\delta_{\mu\nu}\delta_{\mu\nu} - \frac{q_\mu q_\nu}{q_\mu{}^2}k_\mu k_\nu{}'\right.$$

$$\left. - \frac{q_\mu q_\nu}{q_\mu{}^2}k_\mu k_\nu{}' \quad \frac{q_\mu q_\nu}{q_\mu{}^2} \;.\; 1/2q_\mu{}^2\delta_{\mu\nu}\right]$$

$$= 2\left[2k\cdot k' + 3/2q^2 - \frac{2(q.k)(q_\mu.k')}{q_\mu{}^2}\right] \qquad \ldots(L.5.2)$$

Dari hubungan :

$$k \cdot k' = -1/2q_\mu^2 - m^2 \qquad \text{...(L.5.3a)}$$

$$q \cdot k = -1/2q_\mu^2 \qquad \text{...(L.5.3b)}$$

$$q \cdot k' = 1/2q_\mu^2 \qquad \text{....(L.5.3c)}$$

maka diperoleh :

$$G = 2(q_\mu^2 - 2m^2) \qquad \text{....(L.5.4)}$$

Koefisien suku kedua persamaan (L.5.1) memberikan :

$$H = 2(k_\mu k_\nu' + k_\nu k_\mu' + 1/2q_\mu^2 \delta_{\mu\nu})\left\{P_\mu - \frac{q.P}{q_\mu^2} q_\mu\right\}$$

$$\left\{P_\nu - \frac{q.P}{q_\mu^2} q_\nu\right\}$$

$$= 2(k_\mu k_\nu' + k_\nu k_\mu' + 1/2q_\mu^2 \delta_{\mu\nu})\left\{P_\mu P_\nu - \frac{q.P}{q_\mu^2} P_\nu q_\mu\right.$$

$$\left. - \frac{q.P}{q_\mu^2} q_\nu P_\mu - \frac{q.P^2}{q_\mu^4} q_\mu P_\nu\right\}$$

$$= 2\{P_\mu P_\nu (k_\mu k_\nu' + k_\nu k_\mu' + 1/2q_\mu^2 \delta_{\mu\nu}) - \frac{q.P}{q_\mu^2} P_\nu q_\mu$$

$$x\ (k_\mu k_\nu' + k_\nu k_\mu' + 1/2q_\mu^2 \delta_{\mu\nu}) - \frac{q.P}{q_\mu^2} q_\nu P_\mu$$

$$(k_\mu k_\nu' + k_\nu k_\mu' + 1/2q_\mu^2 \delta_{\mu\nu})$$

$$+ \frac{q.P}{q_\mu^2} q_\mu q_\nu\ (k_\mu k_\nu' + k_\nu k_\mu' + 1/2q_\mu^2 \delta_{\mu\nu})\}$$

$$= 2\Big[2(k.P)(k'.P) + 1/2q_\mu^2\ P_\mu^{\ 2} - \frac{q.P}{q_\mu^{\ 2}}\{(k.P)(k'.q)$$

$$+ (k'.P)(k\ .q)$$

$$+ 1/2q^3P\}$$

$$+ \frac{(q\ .P)^2}{q_\mu^{\ 2}}\{2(k\ .q)(k'.q) + 1/2q_\mu^{\ 4}\}\Big]$$

$$= 2\Big[2(k\ .P)(k'.P) + 1/2q_\mu^2\ P_\mu^{\ 2} - \frac{q.P}{q_\mu^{\ 2}}\{2(k\ .P)k'.q$$

$$+ 2(k\cdot.q)(k'.q) + q^3P\}$$

$$+ \frac{(q\cdot.P)^2}{q_\mu^{\ 2}}\{2(k\ .\cdot q)(k'.q) + 1/2q_\mu^{\ 4}\}\Big] \qquad ....(L.5.5)$$

dari hubungan persamaan (L.5.3) serta :

$$(q\ .\ P)(k+k').P = q\ .(k+k')P^2 = q\ .(qk+q)P^2$$

$$= (2q\ .k + q^2)P^2 = 0 \qquad .....(L.5.6)$$

diperoleh :

$$H = 2\{(k\ .P)(k\ .k').P - 1/2q^2P^2\} \qquad ...(L.5.7)$$

substitusi persamaan (L.5.7) dan persamaan (L.5.4) ke dalam persamaan (L.5.1) diproleh hasil akhir :

$$\eta_{\mu\nu}W_{\mu\nu} = 2(q_\mu^{\ 2}-2m^2)W_1 + 2\{2(k\ .P)(k\ .k') - 1/2q_\mu^{\ 2}\}W_2$$

$$...(L.5.8)$$

LAMPIRAN-6

FAKTOR BENTUK INTI TRANSVERSAL DAN LONGITUDINAL

$$J_\mu(\vec{q})Q_\mu = \sum_{\lambda=\pm1} \{J_\lambda(\vec{q})Q_\lambda^* + J_3(\vec{q})Q_3 + J_4(\vec{q})Q_4\}$$

$$\underset{x_3 / \vec{q}}{====\Rightarrow} \sum_{\lambda=\pm1} \{J_\lambda(\vec{q})Q_\lambda^* + (\frac{\omega}{|\vec{q}|^2})\, \vec{q}.\vec{Q} - \vec{Q}_o\rho(\vec{q})\} \quad (L.6.1)$$

$$J_\nu^*(\vec{q})Q_\nu^* = \sum_{\lambda'=\pm1} \{J_{\lambda'}(\vec{q})Q_{\lambda'} + J_3^*(\vec{q})Q_3^* + J_4^*(\vec{q})Q_4^*\}$$

$$\underset{x_3 // \vec{q}}{====\Rightarrow} \sum_{\lambda'=\pm1} \{J_{\lambda'}(\vec{q})Q_{\lambda'} + (\frac{\omega}{|\vec{q}|^2}\, \vec{q}.\vec{Q} - Q_o)\rho^*(\vec{q})\}$$

.....(L.6.2)

$$J_\nu^*(\vec{q})Q_\nu^* = \sum_{\lambda'=\pm1} \{J_{\lambda'}(\vec{q})J_\lambda^*(\vec{q}) + (\frac{\omega}{|\vec{q}|^2}-1)\, \rho(\vec{q})\rho^*(\vec{q})\}$$

$$m = \frac{1}{2J_i+1}\sum_{M_i}\sum_{M_f} \{ \sum_{\lambda,\lambda'=\pm1} J_{\lambda'}(\vec{q})J_\lambda^*(\vec{q})Q_\lambda^* Q_{\lambda'}$$

$$+ \sum_{\lambda'=\pm1} 2J_{\lambda'}(\vec{q})\, \rho_\lambda(\vec{q})$$

$$\times Q_{\lambda'}(\frac{\omega}{|\vec{q}|^2}\, \vec{q}.\vec{Q} - Q_o)$$

$$+ 1/2\, q_\mu^2 \sum_{\lambda=\pm1} J_\lambda(\vec{q})J_\lambda(\vec{q})\}$$

$$+ \{ 2(\frac{\omega}{|\vec{q}|^2}\, \vec{q}.\vec{Q} - Q_o) - 1/2 q_\mu^2 \frac{q_\nu^2}{|\vec{q}|^2} \}\rho(\vec{q})\rho^*(\vec{q})$$

....(L.6.3)

Dengan menuliskan :

$$\vec{q}\,.\,\vec{Q} = 1/2(k'-k)\,.\,(k'+k) = 1/2(\epsilon'^2-\epsilon^2) = 1/2(\epsilon'+\epsilon)(\epsilon'-\epsilon)$$

$$= 1/2\omega(\epsilon'+\epsilon) \qquad \ldots(L.6.4)$$

dan :

$$Q_o = 1/2(\epsilon'+\epsilon) \qquad \ldots(L.6.5)$$

maka :

$$2(\frac{\omega}{|\vec{q}|^2}\vec{q}.\vec{Q} - Q_o)^2 = 2\{\frac{\omega}{|\vec{q}|^2}(\epsilon'+\epsilon) - 1/2(\epsilon'+\epsilon)^2$$

$$\{\frac{q_\mu^*}{|\vec{q}|}\}^4\} \qquad \ldots(L.6.6)$$

Bentuk :

$$\frac{2}{2J_i+1}\sum_{\lambda',\lambda=\pm1}\sum_{M_i}\sum_{M_f} 2J_\lambda(\vec{q})J_{\lambda'}^*(\vec{q})Q_\lambda^* Q_{\lambda'}$$

$$= \frac{2}{2J_i+1}\sum_{\lambda',\lambda=\pm1}\{\delta_{\lambda\lambda'}(2\pi)\sum_{J\geq1}|<J_f\|\hat{T}_J^{el}(q)\|J_i>|^2$$

$$+ |<J_f\|\hat{T}_J^{mag}(q)\|J_i>|^2\}\{Q_\lambda^* Q_{\lambda'} - Q_3^* Q_3\}$$

$$= \frac{4\pi}{2J_i+1}\sum_{J\geq1}\{|<J_f\|\hat{T}_J^{el}(q)\|J_i>|^2 + |<J_f\|\hat{T}_J^{mag}(q)\|J_i>|^2\}$$

$$\times\{|\vec{Q}|^2 - (\frac{\vec{q}.\vec{Q}}{|\vec{q}|})^2\} \qquad .(L.6.7)$$

Bentuk :

$$\frac{1}{2J_i+1}\sum_{\lambda=\pm1}\sum_{M_i}\sum_{M_f} = (\frac{4\pi}{2J_i+1})\sum_{J\geq1} \times\{|<J_f\|\hat{T}_J^{el}(q)\|J_i>|^2$$

$$+ |<J_f\|\hat{T}_J^{mag}(q)\|J_i>|^2\}$$

$$\ldots(L.6.8)$$

Substitusi persamaan (L.6.6), (L.6.7), (L.6.8) ke dalam persamaan(L.6.4)diperoleh :

$$m = \frac{1}{2J_i+1} \sum_{\lambda=\pm 1} \sum_{M_i M_f} \sum \{2(J_\mu(\vec{q})Q_\mu)(J_\mu^*(\vec{q})Q_\delta)$$

$$+ 1/2q_\mu^2 J_\nu(\vec{q}) J_\nu^*(\vec{q})\}$$

$$= \frac{4\pi}{2J_i+1} \{|\xi|^2 - \frac{(\vec{q}\cdot\vec{Q})^2}{|\vec{q}|^2} + 1/2q_\mu^2\} \sum_{J\geq 1} \{|<J_f\|\hat{T}_J^{el}(q)\|J_i>|^2$$

$$+ |<J_f\|\hat{T}_J^{mag}(q)\|J_i>|^2\}$$

$$\{1/2(\epsilon'+\epsilon)^2 \frac{q_4^4}{|q|^4} - \frac{q_4^4}{|q|^2}\}\rho(\vec{q})\rho^*(\vec{q})$$

$$= \frac{4\pi}{2J_i+1} \sum_{M_i M_f} \sum [\ V_T(\theta) \sum_{J\geq 1} \{|<J_f\|\hat{T}_J^{el}(q)\|J_i>|^2$$

$$+ |<J\ \|\hat{T}_J^{mag}(q)\|J_i>|^2\}$$

$$V_L(\theta) \sum_{J\geq 1} |<J_f\|\hat{T}_J^{coul}(q)\|J_i>|^2\}] \quad .(L.6.9)$$

dengan :

$$V_L(\theta) \equiv 1/2\ \frac{q_\mu^2}{|\vec{q}|^4} \{4Q_o^2 - |\vec{q}|^2\} \quad .(L.6.10a)$$

didefinisikan sebagai kinematika transversal

LAMPIRAN-7

HASIL PENGHITUNGAN

Tabel Perhitungan Numerik
Untuk nuklida : He
Nomor Atom : 2
Nomor Massa : 4
Jari-jari (R) : 2.07
Tebal (t) : 1.40

q	|Fo(q)|
0.00	8.337003E-0001
0.01	7.988586E-0001
0.02	7.131446E-0001
0.03	5.933887E-0001
0.04	4.598826E-0001
0.05	3.305108E-0001
0.06	2.173560E-0001
0.07	1.261598E-0001
0.08	5.764412E-0002
0.09	9.442503E-0003
0.10	2.219311E-0002
0.11	4.122925E-0002
0.12	5.121644E-0002
0.13	5.503703E-0002
0.14	5.487971E-0002
0.15	5.232376E-0002
0.16	4.846060E-0002
0.17	4.401416E-0002
0.18	3.944378E-0002
0.19	3.502506E-0002
0.20	3.091018E-0002
0.21	2.717105E-0002
0.22	2.382931E-0002
0.23	2.087660E-0002
0.24	1.828796E-0002
0.25	1.603036E-0002
0.26	1.406803E-0002
0.27	1.236560E-0002
0.28	1.088986E-0002
0.29	9.610614E-0003
0.30	8.500960E-0003
0.31	7.537313E-0003
0.32	6.699185E-0003
0.33	5.968911E-0003
0.34	5.331331E-0003
0.35	4.773476E-0003
0.36	4.284275E-0003
0.37	3.854281E-0003
0.38	3.475440E-0003
0.39	3.140876E-0003
0.40	2.844720E-0003
0.41	2.581951E-0003
0.42	2.348270E-0003

q	|Fo(q)|
0.43	2.139990E-0003
0.44	1.953939E-0003
0.45	1.787387E-0003
0.46	1.637978E-0003
0.47	1.503673E-0003
0.48	1.382704E-0003
0.49	1.273537E-0003
0.50	1.174836E-0003
0.51	1.085434E-0003
0.52	1.004311E-0003
0.53	9.305748E-0004
0.54	8.634403E-0004
0.55	8.022175E-0004
0.56	7.462979E-0004
0.57	6.951440E-0004
0.58	6.482803E-0004
0.59	6.052852E-0004
0.60	5.657839E-0004
0.61	5.294433E-0004
0.62	4.959663E-0004
0.63	4.650876E-0004
0.64	4.365701E-0004
0.65	4.102011E-0004
0.66	3.857901E-0004
0.67	3.631657E-0004
0.68	3.421738E-0004
0.69	3.226754E-0004
0.70	3.045452E-0004
0.71	2.876697E-0004
0.72	2.719464E-0004
0.73	2.572823E-0004
0.74	2.435931E-0004
0.75	2.308022E-0004
0.76	2.188398E-0004
0.77	2.076424E-0004
0.78	1.971520E-0004
0.79	1.873160E-0004
0.80	1.780858E-0004

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : Li
Nomor Atom : 3
Nomor Massa : 6
Jari-jari (R) : 3.41
Tebal (t) : 2.30

q	|Fo(q)|
0.00	5.726015E-0001
0.01	5.151191E-0001
0.02	3.872253E-0001
0.03	2.385006E-0001
0.04	1.101592E-0001
0.05	2.016792E-0002
0.06	3.243713E-0002
0.07	5.709728E-0002
0.08	6.415314E-0002
0.09	6.163711E-0002
0.10	5.478575E-0002
0.11	4.661521E-0002
0.12	3.866948E-0002
0.13	3.162040E-0002
0.14	2.566842E-0002
0.15	2.078360E-0002
0.16	1.683969E-0002
0.17	1.368344E-0002
0.18	1.116724E-0002
0.19	9.162212E-0003
0.20	7.561477E-0003
0.21	6.279025E-0003
0.22	5.246832E-0003
0.23	4.411641E-0003
0.24	3.731971E-0003
0.25	3.175565E-0003
0.26	2.717329E-0003
0.27	2.337692E-0003
0.28	2.021337E-0003
0.29	1.756225E-0003
0.30	1.532848E-0003
0.31	1.343654E-0003
0.32	1.182613E-0003
0.33	1.044886E-0003
0.34	9.265654E-0004
0.35	8.244797E-0004
0.36	7.360410E-0004
0.37	6.591269E-0004
0.38	5.919879E-0004
0.39	5.331749E-0004
0.40	4.814822E-0004

q	|Fo(q)|
0.41	4.359023E-0004
0.42	3.955894E-0004
0.43	3.598307E-0004
0.44	3.280233E-0004
0.45	2.996551E-0004
0.46	2.742895E-0004
0.47	2.515533E-0004
0.48	2.311263E-0004
0.49	2.127325E-0004
0.50	1.961339E-0004
0.51	1.811243E-0004
0.52	1.675245E-0004
0.53	1.551785E-0004
0.54	1.439501E-0004
0.55	1.337200E-0004
0.56	1.243834E-0004
0.57	1.158483E-0004
0.58	1.080335E-0004
0.59	1.008673E-0004
0.60	9.428592E-0005
0.61	8.823313E-0005
0.62	8.265872E-0005
0.63	7.751800E-0005
0.64	7.277108E-0005
0.65	6.838228E-0005
0.66	6.431965E-0005
0.67	6.055451E-0005
0.68	5.706108E-0005
0.69	5.381615E-0005
0.70	5.079879E-0005
0.71	4.799011E-0005
0.72	4.537302E-0005
0.73	4.293203E-0005
0.74	4.065311E-0005
0.75	3.852351E-0005
0.76	3.653163E-0005
0.77	3.466691E-0005
0.78	3.291974E-0005
0.79	3.128132E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : Be
Nomor Atom : 4
Nomor Massa : 9
Jari-jari (R) : 2.92
Tebal (t) : 2.00

q	|Fo(q)|
0.00	7.722373E-0002
0.01	6.721239E-0002
0.02	4.330689E-0002
0.03	1.181473E-0002
0.04	2.018726E-0002
0.05	4.721719E-0002
0.06	6.642833E-0002
0.07	7.738499E-0002
0.08	8.121011E-0002
0.09	7.969786E-0002
0.10	7.468477E-0002
0.11	6.771977E-0002
0.12	5.995627E-0002
0.13	5.217043E-0002
0.14	4.483292E-0002
0.15	3.819140E-0002
0.16	3.234331E-0002
0.17	2.729243E-0002
0.18	2.298920E-0002
0.19	1.935783E-0002
0.20	1.631325E-0002
0.21	1.377125E-0002
0.22	1.165378E-0002
0.23	9.891501E-0003
0.24	8.424434E-0003
0.25	7.201663E-0003
0.26	6.180539E-0003
0.27	5.325663E-0003
0.28	4.607841E-0003
0.29	4.003102E-0003
0.30	3.491812E-0003
0.31	3.057912E-0003
0.32	2.688269E-0003
0.33	2.372137E-0003
0.34	2.100714E-0003
0.35	1.866773E-0003
0.36	1.664369E-0003
0.37	1.488597E-0003
0.38	1.335401E-0003
0.39	1.201411E-0003
0.40	1.083823E-0003

q	|Fo(q)|
0.41	9.802936E-0004
0.42	8.888558E-0004
0.43	8.078552E-0004
0.44	7.358940E-0004
0.45	6.717873E-0004
0.46	6.145274E-0004
0.47	5.632538E-0004
0.48	5.172297E-0004
0.49	4.758220E-0004
0.50	4.384851E-0004
0.51	4.047471E-0004
0.52	3.741989E-0004
0.53	3.464846E-0004
0.54	3.212941E-0004
0.55	2.983559E-0004
0.56	2.774324E-0004
0.57	2.583144E-0004
0.58	2.408179E-0004
0.59	2.247805E-0004
0.60	2.100582E-0004
0.61	1.965237E-0004
0.62	1.840634E-0004
0.63	1.725767E-0004
0.64	1.619735E-0004
0.65	1.521734E-0004
0.66	1.431045E-0004
0.67	1.347020E-0004
0.68	1.269081E-0004
0.69	1.196706E-0004
0.70	1.129423E-0004
0.71	1.066809E-0004
0.72	1.008480E-0004
0.73	9.540879E-0005
0.74	9.033180E-0005
0.75	8.558845E-0005
0.76	8.115272E-0005
0.77	7.700097E-0005
0.78	7.311163E-0005
0.79	6.946503E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : B
Nomor Atom : 5
Nomor Massa : 11
Jari-jari (R) : 2.90
Tebal (t) : 2.00

q	|Fo(q)|
0.00	6.729115E-0002
0.01	6.989977E-0002
0.02	7.607730E-0002
0.03	8.400847E-0002
0.04	9.153893E-0002
0.05	9.686739E-0002
0.06	9.896306E-0002
0.07	9.762501E-0002
0.08	9.328410E-0002
0.09	8.671181E-0002
0.10	7.876223E-0002
0.11	7.020262E-0002
0.12	6.163303E-0002
0.13	5.347025E-0002
0.14	4.596823E-0002
0.15	3.925313E-0002
0.16	3.336001E-0002
0.17	2.826446E-0002
0.18	2.390723E-0002
0.19	2.021173E-0002
0.20	1.709585E-0002
0.21	1.447920E-0002
0.22	1.228727E-0002
0.23	1.045341E-0002
0.24	8.919470E-0003
0.25	7.635573E-0003
0.26	6.559522E-0003
0.27	5.655932E-0003
0.28	4.895343E-0003
0.29	4.253343E-0003
0.30	3.709774E-0003
0.31	3.248021E-0003
0.32	2.854407E-0003
0.33	2.517676E-0003
0.34	2.228557E-0003
0.35	1.979409E-0003
0.36	1.763921E-0003
0.37	1.576873E-0003
0.38	1.413937E-0003
0.39	1.271513E-0003
0.40	1.146600E-0003

q	|Fo(q)|
0.41	1.036689E-0003
0.42	9.396735E-0004
0.43	8.537816E-0004
0.44	7.775168E-0004
0.45	7.096108E-0004
0.46	6.489857E-0004
0.47	5.947220E-0004
0.48	5.460329E-0004
0.49	5.022428E-0004
0.50	4.627700E-0004
0.51	4.271120E-0004
0.52	3.948333E-0004
0.53	3.655556E-0004
0.54	3.389493E-0004
0.55	3.147261E-0004
0.56	2.926339E-0004
0.57	2.724509E-0004
0.58	2.539821E-0004
0.59	2.370553E-0004
0.60	2.215181E-0004
0.61	2.072357E-0004
0.62	1.940880E-0004
0.63	1.819685E-0004
0.64	1.707820E-0004
0.65	1.604434E-0004
0.66	1.508767E-0004
0.67	1.420135E-0004
0.68	1.337927E-0004
0.69	1.261591E-0004
0.70	1.190630E-0004
0.71	1.124595E-0004
0.72	1.063081E-0004
0.73	1.005722E-0004
0.74	9.521845E-0005
0.75	9.021668E-0005
0.76	8.553944E-0005
0.77	8.116177E-0005
0.78	7.706092E-0005
0.79	7.321611E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : C
Nomor Atom : 6
Nomor Massa : 12
Jari-jari (R) : 3.11
Tebal (t) : 1.85

q	|Fo(q)|
0.00	6.869373E-0001
0.01	6.365377E-0001
0.02	5.183303E-0001
0.03	3.671210E-0001
0.04	2.183228E-0001
0.05	9.530949E-0002
0.06	6.805286E-0003
0.07	4.902726E-0002
0.08	7.904117E-0002
0.09	9.104220E-0002
0.10	9.172869E-0002
0.11	8.606094E-0002
0.12	7.736407E-0002
0.13	6.769161E-0002
0.14	5.820949E-0002
0.15	4.950913E-0002
0.16	4.183298E-0002
0.17	3.522492E-0002
0.18	2.962507E-0002
0.19	2.492651E-0002
0.20	2.100767E-0002
0.21	1.774950E-0002
0.22	1.504370E-0002
0.23	1.279583E-0002
0.24	1.092568E-0002
0.25	9.366249E-0003
0.26	8.062213E-0003
0.27	6.968178E-0003
0.28	6.047061E-0003
0.29	5.268632E-0003
0.30	4.608257E-0003
0.31	4.045854E-0003
0.32	3.565029E-0003
0.33	3.152369E-0003
0.34	2.796873E-0003
0.35	2.489491E-0003
0.36	2.222758E-0003
0.37	1.990491E-0003
0.38	1.787555E-0003
0.39	1.609669E-0003
0.40	1.453251E-0003

q	|Fo(q)|
0.41	1.315294E-0003
0.42	1.193266E-0003
0.43	1.085023E-0003
0.44	9.887514E-0004
0.45	9.029039E-0004
0.46	8.261612E-0004
0.47	7.573930E-0004
0.48	6.956286E-0004
0.49	6.400313E-0004
0.50	5.898785E-0004
0.51	5.445438E-0004
0.52	5.034831E-0004
0.53	4.662223E-0004
0.54	4.323476E-0004
0.55	4.014965E-0004
0.56	3.733509E-0004
0.57	3.476312E-0004
0.58	3.240907E-0004
0.59	3.025114E-0004
0.60	2.827005E-0004
0.61	2.644868E-0004
0.62	2.477182E-0004
0.63	2.322592E-0004
0.64	2.179889E-0004
0.65	2.047991E-0004
0.66	1.925931E-0004
0.67	1.812841E-0004
0.68	1.707940E-0004
0.69	1.610526E-0004
0.70	1.519968E-0004
0.71	1.435693E-0004
0.72	1.357184E-0004
0.73	1.283975E-0004
0.74	1.215642E-0004
0.75	1.151799E-0004
0.76	1.092097E-0004
0.77	1.036218E-0004
0.78	9.838707E-0005
0.79	9.347908E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : N
Nomor Atom : 7
Nomor Massa : 14
Jari-jari (R) : 3.20
Tebal (t) : 1.85

q	|Fo(q)|
0.00	5.375362E-0001
0.01	4.968775E-0001
0.02	4.010039E-0001
0.03	2.772424E-0001
0.04	1.541122E-0001
0.05	5.125822E-0002
0.06	2.322500E-0002
0.07	7.007349E-0002
0.08	9.457943E-0002
0.09	1.032073E-0001
0.10	1.017276E-0001
0.11	9.454127E-0002
0.12	8.466992E-0002
0.13	7.401704E-0002
0.14	6.368093E-0002
0.15	5.422501E-0002
0.16	4.588034E-0002
0.17	3.868493E-0002
0.18	3.257376E-0002
0.19	2.743412E-0002
0.20	2.313781E-0002
0.21	1.955869E-0002
0.22	1.658134E-0002
0.23	1.410453E-0002
0.24	1.204179E-0002
0.25	1.032052E-0002
0.26	8.880519E-0003
0.27	7.672168E-0003
0.28	6.654806E-0003
0.29	5.795189E-0003
0.30	5.066162E-0003
0.31	4.445546E-0003
0.32	3.915208E-0003
0.33	3.460296E-0003
0.34	3.068620E-0003
0.35	2.730150E-0003
0.36	2.436607E-0003
0.37	2.181139E-0003
0.38	1.958052E-0003
0.39	1.762605E-0003
0.40	1.590830E-0003

q	|Fo(q)|
0.41	1.439400E-0003
0.42	1.305512E-0003
0.43	1.186799E-0003
0.44	1.081254E-0003
0.45	9.871712E-0004
0.46	9.030942E-0004
0.47	8.277768E-0004
0.48	7.601493E-0004
0.49	6.992903E-0004
0.50	6.444043E-0004
0.51	5.948023E-0004
0.52	5.498859E-0004
0.53	5.091343E-0004
0.54	4.720927E-0004
0.55	4.383630E-0004
0.56	4.075961E-0004
0.57	3.794851E-0004
0.58	3.537595E-0004
0.59	3.301802E-0004
0.60	3.085357E-0004
0.61	2.886386E-0004
0.62	2.703220E-0004
0.63	2.534376E-0004
0.64	2.378529E-0004
0.65	2.234496E-0004
0.66	2.101216E-0004
0.67	1.977741E-0004
0.68	1.863216E-0004
0.69	1.756872E-0004
0.70	1.658019E-0004
0.71	1.566030E-0004
0.72	1.480341E-0004
0.73	1.400441E-0004
0.74	1.325865E-0004
0.75	1.256195E-0004
0.76	1.191046E-0004
0.77	1.130072E-0004
0.78	1.072954E-0004
0.79	1.019403E-0004
0.80	9.691562E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : Mg
Nomor Atom : 12
Nomor Massa : 24
Jari-jari (R) : 3.85
Tebal (t) : 2.60

q	|Fo(q)|
0.00	5.419386E-0001
0.01	5.162474E-0001
0.02	4.558186E-0001
0.03	3.776817E-0001
0.04	2.985969E-0001
0.05	2.292404E-0001
0.06	1.736053E-0001
0.07	1.312720E-0001
0.08	9.990294E-0002
0.09	7.683763E-0002
0.10	5.979870E-0002
0.11	4.706400E-0002
0.12	3.740800E-0002
0.13	2.998090E-0002
0.14	2.419553E-0002
0.15	1.964175E-0002
0.16	1.602754E-0002
0.17	1.314023E-0002
0.18	1.082153E-0002
0.19	8.951329E-0003
0.20	7.437103E-0003
0.21	6.206742E-0003
0.22	5.203578E-0003
0.23	4.382811E-0003
0.24	3.708875E-0003
0.25	3.153447E-0003
0.26	2.693919E-0003
0.27	2.312211E-0003
0.28	1.993831E-0003
0.29	1.727146E-0003
0.30	1.502800E-0003
0.31	1.313248E-0003
0.32	1.152393E-0003
0.33	1.015299E-0003
0.34	8.979515E-0004
0.35	7.970828E-0004
0.36	7.100202E-0004
0.37	6.345721E-0004
0.38	5.689345E-0004
0.39	5.116174E-0004
0.40	4.613851E-0004

q	|Fo(q)|
0.41	4.172094E-0004
0.42	3.782311E-0004
0.43	3.437298E-0004
0.44	3.130987E-0004
0.45	2.858253E-0004
0.46	2.614745E-0004
0.47	2.396760E-0004
0.48	2.201136E-0004
0.49	2.025158E-0004
0.50	1.866492E-0004
0.51	1.723122E-0004
0.52	1.593305E-0004
0.53	1.475525E-0004
0.54	1.368460E-0004
0.55	1.270957E-0004
0.56	1.182006E-0004
0.57	1.100720E-0004
0.58	1.026317E-0004
0.59	9.581075E-0005
0.60	8.954814E-0005
0.61	8.378980E-0005
0.62	7.848768E-0005
0.63	7.359899E-0005
0.64	6.908559E-0005
0.65	6.491336E-0005
0.66	6.105179E-0005
0.67	5.747348E-0005
0.68	5.415383E-0005
0.69	5.107069E-0005
0.70	4.820410E-0005
0.71	4.553606E-0005
0.72	4.305025E-0005
0.73	4.073194E-0005
0.74	3.856774E-0005
0.75	3.654552E-0005
0.76	3.465423E-0005
0.77	3.288383E-0005
0.78	3.122514E-0005
0.79	2.966981E-0005
0.80	2.821019E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : Al
Nomor Atom : 13
Nomor Massa : 27
Jari-jari (R) : 3.76
Tebal (t) : 2.28

q	|Fo(q)|
0.00	2.841097E-0001
0.01	2.777138E-0001
0.02	2.620241E-0001
0.03	2.400261E-0001
0.04	2.149196E-0001
0.05	1.891632E-0001
0.06	1.642740E-0001
0.07	1.410689E-0001
0.08	1.199574E-0001
0.09	1.011252E-0001
0.10	8.461691E-0002
0.11	7.037219E-0002
0.12	5.825110E-0002
0.13	4.805955E-0002
0.14	3.957437E-0002
0.15	3.256473E-0002
0.16	2.680801E-0002
0.17	2.209985E-0002
0.18	1.825935E-0002
0.19	1.513064E-0002
0.20	1.258214E-0002
0.21	1.050448E-0002
0.22	8.807833E-0003
0.23	7.419010E-0003
0.24	6.278795E-0003
0.25	5.339469E-0003
0.26	4.562691E-0003
0.27	3.917700E-0003
0.28	3.379833E-0003
0.29	2.929304E-0003
0.30	2.550226E-0003
0.31	2.229816E-0003
0.32	1.957768E-0003
0.33	1.725750E-0003
0.34	1.527005E-0003
0.35	1.356033E-0003
0.36	1.208344E-0003
0.37	1.080257E-0003
0.38	9.687425E-0004
0.39	8.712966E-0004
0.40	7.858431E-0004

q	|Fo(q)|
0.41	7.106522E-0004
0.42	6.442771E-0004
0.43	5.855032E-0004
0.44	5.333064E-0004
0.45	4.868201E-0004
0.46	4.453084E-0004
0.47	4.081435E-0004
0.48	3.747889E-0004
0.49	3.447835E-0004
0.50	3.177305E-0004
0.51	2.932870E-0004
0.52	2.711558E-0004
0.53	2.510784E-0004
0.54	2.328299E-0004
0.55	2.162132E-0004
0.56	2.010561E-0004
0.57	1.872069E-0004
0.58	1.745322E-0004
0.59	1.629143E-0004
0.60	1.522490E-0004
0.61	1.424438E-0004
0.62	1.334167E-0004
0.63	1.250947E-0004
0.64	1.174125E-0004
0.65	1.103120E-0004
0.66	1.037410E-0004
0.67	9.765276E-0005
0.68	9.200525E-0005
0.69	8.676069E-0005
0.70	8.188504E-0005
0.71	7.734754E-0005
0.72	7.312039E-0005
0.73	6.917846E-0005
0.74	6.549891E-0005
0.75	6.206105E-0005
0.76	5.884606E-0005
0.77	5.583679E-0005
0.78	5.301764E-0005
0.79	5.037437E-0005
0.80	4.789394E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : Si
Nomor Atom : 14
Nomor Massa : 28
Jari-jari (R) : 3.93
Tebal (t) : 2.23

q	|Fo(q)|
0.00	1.367266E-0001
0.01	1.408712E-0001
0.02	1.497770E-0001
0.03	1.589212E-0001
0.04	1.639787E-0001
0.05	1.626270E-0001
0.06	1.548347E-0001
0.07	1.421016E-0001
0.08	1.264735E-0001
0.09	1.098394E-0001
0.10	9.360817E-0002
0.11	7.866024E-0002
0.12	6.543679E-0002
0.13	5.406804E-0002
0.14	4.449105E-0002
0.15	3.653916E-0002
0.16	3.000247E-0002
0.17	2.466468E-0002
0.18	2.032341E-0002
0.19	1.679957E-0002
0.20	1.394022E-0002
0.21	1.161785E-0002
0.22	9.727891E-0003
0.23	8.185538E-0003
0.24	6.922552E-0003
0.25	5.884288E-0003
0.26	5.027121E-0003
0.27	4.316264E-0003
0.28	3.723984E-0003
0.29	3.228146E-0003
0.30	2.811059E-0003
0.31	2.458542E-0003
0.32	2.159200E-0003
0.33	1.903845E-0003
0.34	1.685039E-0003
0.35	1.496742E-0003
0.36	1.334023E-0003
0.37	1.192845E-0003
0.38	1.069885E-0003
0.39	9.624002E-0004
0.40	8.681118E-0004

q	|Fo(q)|
0.41	7.851225E-0004
0.42	7.118443E-0004
0.43	6.469432E-0004
0.44	5.892939E-0004
0.45	5.379434E-0004
0.46	4.920819E-0004
0.47	4.510185E-0004
0.48	4.141618E-0004
0.49	3.810040E-0004
0.50	3.511074E-0004
0.51	3.240935E-0004
0.52	2.996346E-0004
0.53	2.774452E-0004
0.54	2.572769E-0004
0.55	2.389122E-0004
0.56	2.221606E-0004
0.57	2.068547E-0004
0.58	1.928470E-0004
0.59	1.800073E-0004
0.60	1.682206E-0004
0.61	1.573847E-0004
0.62	1.474088E-0004
0.63	1.382122E-0004
0.64	1.297228E-0004
0.65	1.218764E-0004
0.66	1.146152E-0004
0.67	1.078875E-0004
0.68	1.016470E-0004
0.69	9.585188E-0005
0.70	9.046443E-0005
0.71	8.545071E-0005
0.72	8.077998E-0005
0.73	7.642444E-0005
0.74	7.235887E-0005
0.75	6.856039E-0005
0.76	6.500820E-0005
0.77	6.168335E-0005
0.78	5.856859E-0005
0.79	5.564818E-0005
0.80	5.290772E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : P
Nomor Atom : 15
Nomor Massa : 31
Jari-jari (R) : 3.96
Tebal (t) : 2.45

q	|Fo(q)|
0.00	3.386406E-0001
0.01	3.274699E-0001
0.02	3.007710E-0001
0.03	2.650954E-0001
0.04	2.270080E-0001
0.05	1.909243E-0001
0.06	1.588875E-0001
0.07	1.313700E-0001
0.08	1.081132E-0001
0.09	8.863054E-0002
0.10	7.241765E-0002
0.11	5.901151E-0002
0.12	4.799643E-0002
0.13	3.900002E-0002
0.14	3.169064E-0002
0.15	2.577669E-0002
0.16	2.100616E-0002
0.17	1.716492E-0002
0.18	1.407403E-0002
0.19	1.158597E-0002
0.20	9.580519E-0003
0.21	7.960613E-0003
0.22	6.648407E-0003
0.23	5.581800E-0003
0.24	4.711424E-0003
0.25	3.998118E-0003
0.26	3.410846E-0003
0.27	2.925012E-0003
0.28	2.521108E-0003
0.29	2.183632E-0003
0.30	1.900243E-0003
0.31	1.661088E-0003
0.32	1.458272E-0003
0.33	1.285450E-0003
0.34	1.137502E-0003
0.35	1.010280E-0003
0.36	9.004079E-0004
0.37	8.051265E-0004
0.38	7.221711E-0004
0.39	6.496744E-0004
0.40	5.860894E-0004
0.41	5.301295E-0004
0.42	4.807195E-0004
0.43	4.369570E-0004
0.44	3.980820E-0004

q	|Fo(q)|
0.45	3.634513E-0004
0.46	3.325186E-0004
0.47	3.048183E-0004
0.48	2.799519E-0004
0.49	2.575774E-0004
0.50	2.374001E-0004
0.51	2.191653E-0004
0.52	2.026522E-0004
0.53	1.876689E-0004
0.54	1.740480E-0004
0.55	1.616432E-0004
0.56	1.503261E-0004
0.57	1.399842E-0004
0.58	1.305180E-0004
0.59	1.218399E-0004
0.60	1.138724E-0004
0.61	1.065466E-0004
0.62	9.980140E-0005
0.63	9.358237E-0005
0.64	8.784096E-0005
0.65	8.253374E-0005
0.66	7.762185E-0005
0.67	7.307044E-0005
0.68	6.884817E-0005
0.69	6.492686E-0005
0.70	6.128110E-0005
0.71	5.788795E-0005
0.72	5.472668E-0005
0.73	5.177851E-0005
0.74	4.902640E-0005
0.75	4.645492E-0005
0.76	4.404999E-0005
0.77	4.179884E-0005
0.78	3.968979E-0005
0.79	3.771222E-0005
0.80	3.585640E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : Ca
Nomor Atom : 20
Nomor Massa : 40
Jari-jari (R) : 4.55
Tebal (t) : 2.50

q	|Fo(q)|
0.00	3.501794E-0001
0.01	3.402731E-0001
0.02	3.162410E-0001
0.03	2.831953E-0001
0.04	2.464421E-0001
0.05	2.099052E-0001
0.06	1.758881E-0001
0.07	1.455035E-0001
0.08	1.191406E-0001
0.09	9.677265E-0002
0.10	7.813406E-0002
0.11	6.282974E-0002
0.12	5.040955E-0002
0.13	4.042008E-0002
0.14	3.243771E-0002
0.15	2.608655E-0002
0.16	2.104532E-0002
0.17	1.704677E-0002
0.18	1.387314E-0002
0.19	1.134960E-0002
0.20	9.337344E-0003
0.21	7.726977E-0003
0.22	6.432757E-0003
0.23	5.387683E-0003
0.24	4.539472E-0003
0.25	3.847339E-0003
0.26	3.279435E-0003
0.27	2.810844E-0003
0.28	2.422021E-0003
0.29	2.097588E-0003
0.30	1.825398E-0003
0.31	1.595820E-0003
0.32	1.401179E-0003
0.33	1.235337E-0003
0.34	1.093354E-0003
0.35	9.712415E-0004
0.36	8.657584E-0004
0.37	7.742602E-0004
0.38	6.945778E-0004
0.39	6.249236E-0004
0.40	5.638170E-0004
0.41	5.100263E-0004
0.42	4.625222E-0004

q	|Fo(q)|
0.43	4.204406E-0004
0.44	3.830531E-0004
0.45	3.497432E-0004
0.46	3.199872E-0004
0.47	2.933382E-0004
0.48	2.694138E-0004
0.49	2.478857E-0004
0.50	2.284706E-0004
0.51	2.109240E-0004
0.52	1.950336E-0004
0.53	1.806150E-0004
0.54	1.675071E-0004
0.55	1.555693E-0004
0.56	1.446782E-0004
0.57	1.347254E-0004
0.58	1.256153E-0004
0.59	1.172636E-0004
0.60	1.095957E-0004
0.61	1.025453E-0004
0.62	9.605374E-0005
0.63	9.006850E-0005
0.64	8.454288E-0005
0.65	7.943513E-0005
0.66	7.470783E-0005
0.67	7.032745E-0005
0.68	6.626383E-0005
0.69	6.248985E-0005
0.70	5.898106E-0005
0.71	5.571538E-0005
0.72	5.267286E-0005
0.73	4.983542E-0005
0.74	4.718668E-0005
0.75	4.471177E-0005
0.76	4.239716E-0005
0.77	4.023055E-0005
0.78	3.820070E-0005
0.79	3.629738E-0005
0.80	3.451123E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : Ca
Nomor Atom : 20
Nomor Massa : 42
Jari-jari (R) : 4.51
Tebal (t) : 2.30

q	|Fo(q)|
0.00	5.582447E-0002
0.01	6.990147E-0002
0.02	1.007280E-0001
0.03	1.347352E-0001
0.04	1.599762E-0001
0.05	1.709581E-0001
0.06	1.682920E-0001
0.07	1.558163E-0001
0.08	1.379474E-0001
0.09	1.182633E-0001
0.10	9.912018E-0002
0.11	8.180325E-0002
0.12	6.683970E-0002
0.13	5.429321E-0002
0.14	4.398146E-0002
0.15	3.561645E-0002
0.16	2.888576E-0002
0.17	2.349476E-0002
0.18	1.918496E-0002
0.19	1.573908E-0002
0.20	1.297937E-0002
0.21	1.076295E-0002
0.22	8.976257E-0003
0.23	7.529701E-0003
0.24	6.352875E-0003
0.25	5.390559E-0003
0.26	4.599448E-0003
0.27	3.945548E-0003
0.28	3.402112E-0003
0.29	2.948038E-0003
0.30	2.566614E-0003
0.31	2.244558E-0003
0.32	1.971264E-0003
0.33	1.738226E-0003
0.34	1.538589E-0003
0.35	1.366803E-0003
0.36	1.218353E-0003
0.37	1.089545E-0003
0.38	9.773481E-0004
0.39	8.792577E-0004
0.40	7.931980E-0004
0.41	7.174401E-0004
0.42	6.505374E-0004
0.43	5.912747E-0004
0.44	5.386268E-0004
0.45	4.917256E-0004
0.46	4.498331E-0004
0.47	4.123196E-0004
0.48	3.786460E-0004
0.49	3.483492E-0004
0.50	3.210300E-0004
0.51	2.963433E-0004
0.52	2.739898E-0004
0.53	2.537093E-0004
0.54	2.352749E-0004
0.55	2.184882E-0004
0.56	2.031752E-0004
0.57	1.891831E-0004
0.58	1.763772E-0004
0.59	1.646386E-0004
0.60	1.538622E-0004
0.61	1.439547E-0004
0.62	1.348333E-0004
0.63	1.264241E-0004
0.64	1.186614E-0004
0.65	1.114863E-0004
0.66	1.048461E-0004
0.67	9.869375E-0005
0.68	9.298670E-0005
0.69	8.768680E-0005
0.70	8.275963E-0005
0.71	7.817415E-0005
0.72	7.390227E-0005
0.73	6.991857E-0005
0.74	6.620002E-0005
0.75	6.272568E-0005
0.76	5.947655E-0005
0.77	5.643531E-0005
0.78	5.358619E-0005
0.79	5.091479E-0005
0.80	4.840796E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : V
Nomor Atom : 23
Nomor Massa : 51
Jari-jari (R) : 4.63
Tebal (t) : 2.20

q	|Fo(q)|
0.00	2.743139E-0001
0.01	2.742283E-0001
0.02	2.726593E-0001
0.03	2.669835E-0001
0.04	2.551984E-0001
0.05	2.370643E-0001
0.06	2.139969E-0001
0.07	1.882348E-0001
0.08	1.620004E-0001
0.09	1.370113E-0001
0.10	1.143427E-0001
0.11	9.450365E-0002
0.12	7.759190E-0002
0.13	6.344947E-0002
0.14	5.178466E-0002
0.15	4.225555E-0002
0.16	3.452074E-0002
0.17	2.826663E-0002
0.18	2.321919E-0002
0.19	1.914674E-0002
0.20	1.585771E-0002
0.21	1.319608E-0002
0.22	1.103613E-0002
0.23	9.277281E-0003
0.24	7.839445E-0003
0.25	6.658993E-0003
0.26	5.685443E-0003
0.27	4.878738E-0003
0.28	4.207058E-0003
0.29	3.645080E-0003
0.30	3.172603E-0003
0.31	2.773465E-0003
0.32	2.434692E-0003
0.33	2.145830E-0003
0.34	1.898424E-0003
0.35	1.685607E-0003
0.36	1.501782E-0003
0.37	1.342361E-0003
0.38	1.203574E-0003
0.39	1.082305E-0003
0.40	9.759692E-0004
0.41	8.824143E-0004
0.42	7.998392E-0004

q	|Fo(q)|
0.43	7.267316E-0004
0.44	6.618161E-0004
0.45	6.040132E-0004
0.46	5.524058E-0004
0.47	5.062119E-0004
0.48	4.647623E-0004
0.49	4.274827E-0004
0.50	3.938782E-0004
0.51	3.635213E-0004
0.52	3.360417E-0004
0.53	3.111173E-0004
0.54	2.884675E-0004
0.55	2.678471E-0004
0.56	2.490411E-0004
0.57	2.318609E-0004
0.58	2.161403E-0004
0.59	2.017327E-0004
0.60	1.885083E-0004
0.61	1.763522E-0004
0.62	1.651623E-0004
0.63	1.548477E-0004
0.64	1.453274E-0004
0.65	1.365288E-0004
0.66	1.283873E-0004
0.67	1.208448E-0004
0.68	1.138489E-0004
0.69	1.073529E-0004
0.70	1.013143E-0004
0.71	9.569500E-0005
0.72	9.046050E-0005
0.73	8.557955E-0005
0.74	8.102384E-0005
0.75	7.676767E-0005
0.76	7.278769E-0005
0.77	6.906264E-0005
0.78	6.557314E-0005
0.79	6.230153E-0005
0.80	5.923166E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : Fe
Nomor Atom : 26
Nomor Massa : 56
Jari-jari (R) : 4.84
Tebal (t) : 2.50

q	|Fo(q)|
0.00	6.022199E-0001
0.01	5.774623E-0001
0.02	5.185130E-0001
0.03	4.405449E-0001
0.04	3.590737E-0001
0.05	2.847347E-0001
0.06	2.223350E-0001
0.07	1.725072E-0001
0.08	1.337868E-0001
0.09	1.040661E-0001
0.10	8.132633E-0002
0.11	6.389612E-0002
0.12	5.047961E-0002
0.13	4.010029E-0002
0.14	3.202910E-0002
0.15	2.572146E-0002
0.16	2.076853E-0002
0.17	1.686147E-0002
0.18	1.376547E-0002
0.19	1.130106E-0002
0.20	9.330388E-0003
0.21	7.747155E-0003
0.22	6.469093E-0003
0.23	5.432323E-0003
0.24	4.587093E-0003
0.25	3.894526E-0003
0.26	3.324149E-0003
0.27	2.851996E-0003
0.28	2.459155E-0003
0.29	2.130645E-0003
0.30	1.854557E-0003
0.31	1.621387E-0003
0.32	1.423518E-0003
0.33	1.254822E-0003
0.34	1.110347E-0003
0.35	9.860749E-0004
0.36	8.787302E-0004
0.37	7.856320E-0004
0.38	7.045765E-0004
0.39	6.337437E-0004
0.40	5.716245E-0004
0.41	5.169623E-0004
0.42	4.687061E-0004

q	|Fo(q)|
0.43	4.259735E-0004
0.44	3.880207E-0004
0.45	3.542181E-0004
0.46	3.240310E-0004
0.47	2.970035E-0004
0.48	2.727456E-0004
0.49	2.509224E-0004
0.50	2.312455E-0004
0.51	2.134657E-0004
0.52	1.973669E-0004
0.53	1.827614E-0004
0.54	1.694856E-0004
0.55	1.573965E-0004
0.56	1.463686E-0004
0.57	1.362919E-0004
0.58	1.270692E-0004
0.59	1.186152E-0004
0.60	1.108539E-0004
0.61	1.037183E-0004
0.62	9.714857E-0005
0.63	9.109173E-0005
0.64	8.550036E-0005
0.65	8.033212E-0005
0.66	7.554910E-0005
0.67	7.111729E-0005
0.68	6.700617E-0005
0.69	6.318823E-0005
0.70	5.963873E-0005
0.71	5.633528E-0005
0.72	5.325769E-0005
0.73	5.038765E-0005
0.74	4.770857E-0005
0.75	4.520539E-0005
0.76	4.286441E-0005
0.77	4.067318E-0005
0.78	3.862032E-0005
0.79	3.669548E-0005
0.80	3.488919E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : Ni
Nomor Atom : 28
Nomor Massa : 58
Jari-jari (R) : 4.92
Tebal (t) : 2.50

q	|Fo(q)|
0.00	5.791478E-0001
0.01	5.558715E-0001
0.02	5.004180E-0001
0.03	4.269679E-0001
0.04	3.499983E-0001
0.05	2.794313E-0001
0.06	2.197888E-0001
0.07	1.717437E-0001
0.08	1.340354E-0001
0.09	1.047946E-0001
0.10	8.220712E-0002
0.11	6.475049E-0002
0.12	5.122524E-0002
0.13	4.071138E-0002
0.14	3.250948E-0002
0.15	2.608811E-0002
0.16	2.104240E-0002
0.17	1.706274E-0002
0.18	1.391160E-0002
0.19	1.140622E-0002
0.20	9.405617E-0003
0.21	7.800802E-0003
0.22	6.507340E-0003
0.23	5.459674E-0003
0.24	4.606782E-0003
0.25	3.908851E-0003
0.26	3.334728E-0003
0.27	2.859960E-0003
0.28	2.465286E-0003
0.29	2.135485E-0003
0.30	1.858478E-0003
0.31	1.624643E-0003
0.32	1.426284E-0003
0.33	1.257217E-0003
0.34	1.112455E-0003
0.35	9.879521E-0004
0.36	8.804180E-0004
0.37	7.871603E-0004
0.38	7.059671E-0004
0.39	6.350138E-0004
0.40	5.727875E-0004
0.41	5.180292E-0004
0.42	4.696864E-0004

q	|Fo(q)|
0.43	4.268752E-0004
0.44	3.888509E-0004
0.45	3.549833E-0004
0.46	3.247368E-0004
0.47	2.976552E-0004
0.48	2.733479E-0004
0.49	2.514795E-0004
0.50	2.317613E-0004
0.51	2.139437E-0004
0.52	1.978104E-0004
0.53	1.831734E-0004
0.54	1.698686E-0004
0.55	1.577529E-0004
0.56	1.467007E-0004
0.57	1.366016E-0004
0.58	1.273585E-0004
0.59	1.188855E-0004
0.60	1.111068E-0004
0.61	1.039551E-0004
0.62	9.737066E-0005
0.63	9.130015E-0005
0.64	8.569614E-0005
0.65	8.051619E-0005
0.66	7.572232E-0005
0.67	7.128045E-0005
0.68	6.715997E-0005
0.69	6.333335E-0005
0.70	5.977576E-0005
0.71	5.646479E-0005
0.72	5.338017E-0005
0.73	5.050358E-0005
0.74	4.781838E-0005
0.75	4.530947E-0005
0.76	4.296314E-0005
0.77	4.076689E-0005
0.78	3.870933E-0005
0.79	3.678008E-0005
0.80	3.496965E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : Ni
Nomor Atom : 28
Nomor Massa : 60
Jari-jari (R) : 4.96
Tebal (t) : 2.50

q	|Fo(q)|
0.00	5.735478E-0001
0.01	5.506903E-0001
0.02	4.962160E-0001
0.03	4.240078E-0001
0.04	3.482395E-0001
0.05	2.786357E-0001
0.06	2.196518E-0001
0.07	1.719886E-0001
0.08	1.344556E-0001
0.09	1.052576E-0001
0.10	8.263978E-0002
0.11	6.512033E-0002
0.12	5.152406E-0002
0.13	4.094364E-0002
0.14	3.268504E-0002
0.15	2.621810E-0002
0.16	2.113716E-0002
0.17	1.713102E-0002
0.18	1.396040E-0002
0.19	1.144091E-0002
0.20	9.430213E-0003
0.21	7.818246E-0003
0.22	6.519756E-0003
0.23	5.468573E-0003
0.24	4.613229E-0003
0.25	3.913592E-0003
0.26	3.338280E-0003
0.27	2.862680E-0003
0.28	2.467420E-0003
0.29	2.137201E-0003
0.30	1.859892E-0003
0.31	1.625833E-0003
0.32	1.427305E-0003
0.33	1.258107E-0003
0.34	1.113240E-0003
0.35	9.886523E-0004
0.36	8.810467E-0004
0.37	7.877277E-0004
0.38	7.064816E-0004
0.39	6.354815E-0004
0.40	5.732139E-0004
0.41	5.184186E-0004
0.42	4.700425E-0004

q	|Fo(q)|
0.43	4.272014E-0004
0.44	3.891501E-0004
0.45	3.552580E-0004
0.46	3.249895E-0004
0.47	2.978878E-0004
0.48	2.735622E-0004
0.49	2.516772E-0004
0.50	2.319440E-0004
0.51	2.141127E-0004
0.52	1.979669E-0004
0.53	1.833184E-0004
0.54	1.700033E-0004
0.55	1.578781E-0004
0.56	1.468172E-0004
0.57	1.367101E-0004
0.58	1.274597E-0004
0.59	1.189800E-0004
0.60	1.111952E-0004
0.61	1.040378E-0004
0.62	9.744809E-0005
0.63	9.137277E-0005
0.64	8.576430E-0005
0.65	8.058024E-0005
0.66	7.578255E-0005
0.67	7.133715E-0005
0.68	6.721340E-0005
0.69	6.338374E-0005
0.70	5.982332E-0005
0.71	5.650971E-0005
0.72	5.342264E-0005
0.73	5.054376E-0005
0.74	4.785642E-0005
0.75	4.534552E-0005
0.76	4.299732E-0005
0.77	4.079932E-0005
0.78	3.874013E-0005
0.79	3.680934E-0005
0.80	3.499747E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : Co
Nomor Atom : 27
Nomor Massa : 59
Jari-jari (R) : 4.94
Tebal (t) : 2.50

q	|Fo(q)|
0.00	5.888683E-0001
0.01	5.650722E-0001
0.02	5.083820E-0001
0.03	4.333064E-0001
0.04	3.546707E-0001
0.05	2.826444E-0001
0.06	2.218617E-0001
0.07	1.730008E-0001
0.08	1.347490E-0001
0.09	1.051680E-0001
0.10	8.237965E-0002
0.11	6.481169E-0002
0.12	5.122955E-0002
0.13	4.069012E-0002
0.14	3.247965E-0002
0.15	2.605820E-0002
0.16	2.101611E-0002
0.17	1.704123E-0002
0.18	1.389479E-0002
0.19	1.139348E-0002
0.20	9.396190E-0003
0.21	7.793946E-0003
0.22	6.502422E-0003
0.23	5.456180E-0003
0.24	4.604315E-0003
0.25	3.907114E-0003
0.26	3.333502E-0003
0.27	2.859086E-0003
0.28	2.464655E-0003
0.29	2.135017E-0003
0.30	1.858121E-0003
0.31	1.624360E-0003
0.32	1.426050E-0003
0.33	1.257017E-0003
0.34	1.112278E-0003
0.35	9.877924E-0004
0.36	8.802710E-0004
0.37	7.870232E-0004
0.38	7.058386E-0004
0.39	6.348927E-0004
0.40	5.726733E-0004
0.41	5.179215E-0004
0.42	4.695848E-0004
0.43	4.267795E-0004
0.44	3.887609E-0004
0.45	3.548986E-0004
0.46	3.246574E-0004
0.47	2.975806E-0004
0.48	2.732779E-0004
0.49	2.514139E-0004
0.50	2.316998E-0004
0.51	2.138861E-0004
0.52	1.977564E-0004
0.53	1.831227E-0004
0.54	1.698211E-0004
0.55	1.577084E-0004
0.56	1.466589E-0004
0.57	1.365624E-0004
0.58	1.273216E-0004
0.59	1.188508E-0004
0.60	1.110742E-0004
0.61	1.039244E-0004
0.62	9.734172E-0005
0.63	9.127287E-0005
0.64	8.567041E-0005
0.65	8.049190E-0005
0.66	7.569937E-0005
0.67	7.125876E-0005
0.68	6.713946E-0005
0.69	6.331394E-0005
0.70	5.975737E-0005
0.71	5.644736E-0005
0.72	5.336365E-0005
0.73	5.048790E-0005
0.74	4.780349E-0005
0.75	4.529533E-0005
0.76	4.294970E-0005
0.77	4.075410E-0005
0.78	3.869716E-0005
0.79	3.676849E-0005
0.80	3.495860E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : Sr
Nomor Atom : 38
Nomor Massa : 88
Jari-jari (R) : 5.35
Tebal (t) : 2.30

q	|Fo(q)|
0.00	2.216863E-0001
0.01	2.286116E-0001
0.02	2.422288E-0001
0.03	2.531055E-0001
0.04	2.538033E-0001
0.05	2.422169E-0001
0.06	2.207184E-0001
0.07	1.935567E-0001
0.08	1.647599E-0001
0.09	1.371964E-0001
0.10	1.124844E-0001
0.11	9.127537E-0002
0.12	7.360386E-0002
0.13	5.917215E-0002
0.14	4.754202E-0002
0.15	3.824813E-0002
0.16	3.085669E-0002
0.17	2.499046E-0002
0.18	2.033475E-0002
0.19	1.663398E-0002
0.20	1.368410E-0002
0.21	1.132407E-0002
0.22	9.427668E-0003
0.23	7.896362E-0003
0.24	6.653383E-0003
0.25	5.638924E-0003
0.26	4.806337E-0003
0.27	4.119163E-0003
0.28	3.548818E-0003
0.29	3.072817E-0003
0.30	2.673400E-0003
0.31	2.336479E-0003
0.32	2.050824E-0003
0.33	1.807444E-0003
0.34	1.599105E-0003
0.35	1.419956E-0003
0.36	1.265242E-0003
0.37	1.131079E-0003
0.38	1.014281E-0003
0.39	9.122188E-0004
0.40	8.227158E-0004
0.41	7.439601E-0004
0.42	6.744369E-0004

q	|Fo(q)|
0.43	6.128749E-0004
0.44	5.582022E-0004
0.45	5.095118E-0004
0.46	4.660331E-0004
0.47	4.271090E-0004
0.48	3.921773E-0004
0.49	3.607552E-0004
0.50	3.324268E-0004
0.51	3.068327E-0004
0.52	2.836616E-0004
0.53	2.626425E-0004
0.54	2.435394E-0004
0.55	2.261461E-0004
0.56	2.102816E-0004
0.57	1.957873E-0004
0.58	1.825231E-0004
0.59	1.703658E-0004
0.60	1.592059E-0004
0.61	1.489468E-0004
0.62	1.395023E-0004
0.63	1.307960E-0004
0.64	1.227596E-0004
0.65	1.153321E-0004
0.66	1.084587E-0004
0.67	1.020907E-0004
0.68	9.618390E-0005
0.69	9.069880E-0005
0.70	8.559973E-0005
0.71	8.085450E-0005
0.72	7.643399E-0005
0.73	7.231188E-0005
0.74	6.846429E-0005
0.75	6.486953E-0005
0.76	6.150791E-0005
0.77	5.836149E-0005
0.78	5.541394E-0005
0.79	5.265034E-0005
0.80	5.005707E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : In
Nomor Atom : 49
Nomor Massa : 115
Jari-jari (R) : 5.81
Tebal (t) : 2.30

q	|Fo(q)|
0.00	9.183101E-0002
0.01	1.134299E-0001
0.02	1.589926E-0001
0.03	2.054226E-0001
0.04	2.346938E-0001
0.05	2.410616E-0001
0.06	2.283249E-0001
0.07	2.039109E-0001
0.08	1.747051E-0001
0.09	1.454681E-0001
0.10	1.188419E-0001
0.11	9.593043E-0002
0.12	7.690804E-0002
0.13	6.147135E-0002
0.14	4.912310E-0002
0.15	3.932941E-0002
0.16	3.159608E-0002
0.17	2.549851E-0002
0.18	2.068718E-0002
0.19	1.688189E-0002
0.20	1.386166E-0002
0.21	1.145397E-0002
0.22	9.524958E-0003
0.23	7.971025E-0003
0.24	6.712067E-0003
0.25	5.686088E-0003
0.26	4.845004E-0003
0.27	4.151411E-0003
0.28	3.576102E-0003
0.29	3.096175E-0003
0.30	2.693591E-0003
0.31	2.354070E-0003
0.32	2.066249E-0003
0.33	1.821044E-0003
0.34	1.611152E-0003
0.35	1.430669E-0003
0.36	1.274803E-0003
0.37	1.139640E-0003
0.38	1.021968E-0003
0.39	9.191409E-0004
0.40	8.289654E-0004
0.41	7.496163E-0004
0.42	6.795683E-0004

q	|Fo(q)|
0.43	6.175405E-0004
0.44	5.624536E-0004
0.45	5.133937E-0004
0.46	4.695847E-0004
0.47	4.303647E-0004
0.48	3.951672E-0004
0.49	3.635059E-0004
0.50	3.349617E-0004
0.51	3.091727E-0004
0.52	2.858249E-0004
0.53	2.646456E-0004
0.54	2.453969E-0004
0.55	2.278709E-0004
0.56	2.118855E-0004
0.57	1.972806E-0004
0.58	1.839153E-0004
0.59	1.716652E-0004
0.60	1.604202E-0004
0.61	1.500828E-0004
0.62	1.405664E-0004
0.63	1.317937E-0004
0.64	1.236960E-0004
0.65	1.162118E-0004
0.66	1.092860E-0004
0.67	1.028694E-0004
0.68	9.691755E-0005
0.69	9.139061E-0005
0.70	8.625265E-0005
0.71	8.147122E-0005
0.72	7.701700E-0005
0.73	7.286344E-0005
0.74	6.898650E-0005
0.75	6.536432E-0005
0.76	6.197706E-0005
0.77	5.880665E-0005
0.78	5.583661E-0005
0.79	5.305193E-0005
0.80	5.043888E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : Sn
Nomor Atom : 50
Nomor Massa : 116
Jari-jari (R) : 5.88
Tebal (t) : 2.37

q	|Fo(q)|
0.00	2.024879E-0001
0.01	2.138628E-0001
0.02	2.364973E-0001
0.03	2.558523E-0001
0.04	2.611930E-0001
0.05	2.501618E-0001
0.06	2.266389E-0001
0.07	1.965593E-0001
0.08	1.650592E-0001
0.09	1.354857E-0001
0.10	1.095230E-0001
0.11	8.769557E-0002
0.12	6.985779E-0002
0.13	5.554694E-0002
0.14	4.419802E-0002
0.15	3.525819E-0002
0.16	2.823827E-0002
0.17	2.272889E-0002
0.18	1.839886E-0002
0.19	1.498591E-0002
0.20	1.228509E-0002
0.21	1.013759E-0002
0.22	8.420888E-0003
0.23	7.040672E-0003
0.24	5.924325E-0003
0.25	5.015864E-0003
0.26	4.272018E-0003
0.27	3.659230E-0003
0.28	3.151368E-0003
0.29	2.727991E-0003
0.30	2.373035E-0003
0.31	2.073806E-0003
0.32	1.820224E-0003
0.33	1.604238E-0003
0.34	1.419386E-0003
0.35	1.260452E-0003
0.36	1.123203E-0003
0.37	1.004186E-0003
0.38	9.005697E-0004
0.39	8.100219E-0004
0.40	7.306106E-0004
0.41	6.607289E-0004
0.42	5.990338E-0004

q	|Fo(q)|
0.43	5.443983E-0004
0.44	4.958723E-0004
0.45	4.526518E-0004
0.46	4.140539E-0004
0.47	3.794961E-0004
0.48	3.484801E-0004
0.49	3.205779E-0004
0.50	2.954208E-0004
0.51	2.726902E-0004
0.52	2.521099E-0004
0.53	2.334396E-0004
0.54	2.164701E-0004
0.55	2.010184E-0004
0.56	1.869241E-0004
0.57	1.740462E-0004
0.58	1.622607E-0004
0.59	1.514580E-0004
0.60	1.415412E-0004
0.61	1.324244E-0004
0.62	1.240311E-0004
0.63	1.162936E-0004
0.64	1.091510E-0004
0.65	1.025494E-0004
0.66	9.644011E-0005
0.67	9.077975E-0005
0.68	8.552921E-0005
0.69	8.065337E-0005
0.70	7.612053E-0005
0.71	7.190211E-0005
0.72	6.797226E-0005
0.73	6.430759E-0005
0.74	6.088688E-0005
0.75	5.769088E-0005
0.76	5.470208E-0005
0.77	5.190456E-0005
0.78	4.928380E-0005
0.79	4.682654E-0005
0.80	4.452068E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : Sb
Nomor Atom : 51
Nomor Massa : 122
Jari-jari (R) : 5.97
Tebal (t) : 2.50

q	|Fo(q)|
0.00	3.924288E-0001
0.01	3.859325E-0001
0.02	3.684871E-0001
0.03	3.405711E-0001
0.04	3.043167E-0001
0.05	2.633481E-0001
0.06	2.216266E-0001
0.07	1.823490E-0001
0.08	1.474782E-0001
0.09	1.178267E-0001
0.10	9.338908E-0002
0.11	7.369092E-0002
0.12	5.805490E-0002
0.13	4.576824E-0002
0.14	3.617218E-0002
0.15	2.869995E-0002
0.16	2.288489E-0002
0.17	1.835363E-0002
0.18	1.481300E-0002
0.19	1.203563E-0002
0.20	9.846623E-0003
0.21	8.111984E-0003
0.22	6.729319E-0003
0.23	5.620379E-0003
0.24	4.725298E-0003
0.25	3.998162E-0003
0.26	3.403645E-0003
0.27	2.914456E-0003
0.28	2.509418E-0003
0.29	2.172018E-0003
0.30	1.889310E-0003
0.31	1.651092E-0003
0.32	1.449277E-0003
0.33	1.277420E-0003
0.34	1.130353E-0003
0.35	1.003913E-0003
0.36	8.947239E-0004
0.37	8.000343E-0004
0.38	7.175904E-0004
0.39	6.455363E-0004
0.40	5.823358E-0004
0.41	5.267115E-0004
0.42	4.775960E-0004
0.43	4.340938E-0004
0.44	3.954499E-0004
0.45	3.610258E-0004
0.46	3.302786E-0004
0.47	3.027456E-0004
0.48	2.780308E-0004
0.49	2.557941E-0004
0.50	2.357424E-0004
0.51	2.176224E-0004
0.52	2.012144E-0004
0.53	1.863276E-0004
0.54	1.727954E-0004
0.55	1.604722E-0004
0.56	1.492304E-0004
0.57	1.389579E-0004
0.58	1.295559E-0004
0.59	1.209372E-0004
0.60	1.130246E-0004
0.61	1.057498E-0004
0.62	9.905189E-0005
0.63	9.287676E-0005
0.64	8.717614E-0005
0.65	8.190688E-0005
0.66	7.703032E-0005
0.67	7.251183E-0005
0.68	6.832027E-0005
0.69	6.442761E-0005
0.70	6.080862E-0005
0.71	5.744050E-0005
0.72	5.430264E-0005
0.73	5.137638E-0005
0.74	4.864482E-0005
0.75	4.609260E-0005
0.76	4.370574E-0005
0.77	4.147156E-0005
0.78	3.937847E-0005
0.79	3.741590E-0005
0.80	3.557419E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : Ta
Nomor Atom : 73
Nomor Massa : 181
Jari-jari (R) : 7.10
Tebal (t) : 2.80

q	|Fo(q)|
0.00	4.380855E-0001
0.01	4.269639E-0001
0.02	3.982982E-0001
0.03	3.554184E-0001
0.04	3.040811E-0001
0.05	2.508349E-0001
0.06	2.009839E-0001
0.07	1.576266E-0001
0.08	1.218386E-0001
0.09	9.335466E-0002
0.10	7.123683E-0002
0.11	5.433530E-0002
0.12	4.154330E-0002
0.13	3.190807E-0002
0.14	2.465924E-0002
0.15	1.919736E-0002
0.16	1.506705E-0002
0.17	1.192751E-0002
0.18	9.525979E-0003
0.19	7.675811E-0003
0.20	6.239417E-0003
0.21	5.115267E-0003
0.22	4.228246E-0003
0.23	3.522563E-0003
0.24	2.956573E-0003
0.25	2.499009E-0003
0.26	2.126250E-0003
0.27	1.820329E-0003
0.28	1.567484E-0003
0.29	1.357100E-0003
0.30	1.180930E-0003
0.31	1.032520E-0003
0.32	9.067828E-0004
0.33	7.996836E-0004
0.34	7.079975E-0004
0.35	6.291319E-0004
0.36	5.609889E-0004
0.37	5.018607E-0004
0.38	4.503489E-0004
0.39	4.053024E-0004
0.40	3.657684E-0004
0.41	3.309543E-0004
0.42	3.001979E-0004

q	|Fo(q)|
0.43	2.729429E-0004
0.44	2.487204E-0004
0.45	2.271332E-0004
0.46	2.078438E-0004
0.47	1.905641E-0004
0.48	1.750474E-0004
0.49	1.610818E-0004
0.50	1.484843E-0004
0.51	1.370970E-0004
0.52	1.267827E-0004
0.53	1.174221E-0004
0.54	1.089111E-0004
0.55	1.011587E-0004
0.56	9.408506E-0005
0.57	8.761996E-0005
0.58	8.170156E-0005
0.59	7.627522E-0005
0.60	7.129260E-0005
0.61	6.671079E-0005
0.62	6.249167E-0005
0.63	5.860129E-0005
0.64	5.500934E-0005
0.65	5.168874E-0005
0.66	4.861522E-0005
0.67	4.576704E-0005
0.68	4.312462E-0005
0.69	4.067037E-0005
0.70	3.838841E-0005
0.71	3.626443E-0005
0.72	3.428547E-0005
0.73	3.243979E-0005
0.74	3.071676E-0005
0.75	2.910671E-0005
0.76	2.760087E-0005
0.77	2.619124E-0005
0.78	2.487053E-0005
0.79	2.363209E-0005
0.80	2.246983E-0005

Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : An
Nomor Atom : 79
Nomor Massa : 197
Jari-jari (R) : 6.87
Tebal (t) : 2.32

q	|Fo(q)|
0.00	2.737355E-0001
0.01	1.995219E-0001
0.02	4.639803E-0002
0.03	1.068714E-0001
0.04	2.092729E-0001
0.05	2.524144E-0001
0.06	2.517786E-0001
0.07	2.270174E-0001
0.08	1.929599E-0001
0.09	1.583095E-0001
0.10	1.271986E-0001
0.11	1.010318E-0001
0.12	7.982459E-0002
0.13	6.300108E-0002
0.14	4.981302E-0002
0.15	3.953460E-0002
0.16	3.153778E-0002
0.17	2.530969E-0002
0.18	2.044484E-0002
0.19	1.662863E-0002
0.20	1.361951E-0002
0.21	1.123306E-0002
0.22	9.328750E-0003
0.23	7.799444E-0003
0.24	6.563328E-0003
0.25	5.557706E-0003
0.26	4.734351E-0003
0.27	4.055985E-0003
0.28	3.493655E-0003
0.29	3.024747E-0003
0.30	2.631508E-0003
0.31	2.299914E-0003
0.32	2.018834E-0003
0.33	1.779373E-0003
0.34	1.574392E-0003
0.35	1.398124E-0003
0.36	1.245887E-0003
0.37	1.113861E-0003
0.38	9.989124E-0004
0.39	8.984568E-0004
0.40	8.103542E-0004
0.41	7.328234E-0004
0.42	6.643757E-0004

q	|Fo(q)|
0.43	6.037610E-0004
0.44	5.499255E-0004
0.45	5.019774E-0004
0.46	4.591587E-0004
0.47	4.208232E-0004
0.48	3.864179E-0004
0.49	3.554677E-0004
0.50	3.275635E-0004
0.51	3.023516E-0004
0.52	2.795255E-0004
0.53	2.588186E-0004
0.54	2.399986E-0004
0.55	2.228625E-0004
0.56	2.072322E-0004
0.57	1.929514E-0004
0.58	1.798823E-0004
0.59	1.679034E-0004
0.60	1.569071E-0004
0.61	1.467981E-0004
0.62	1.374917E-0004
0.63	1.289125E-0004
0.64	1.209932E-0004
0.65	1.136738E-0004
0.66	1.069004E-0004
0.67	1.006248E-0004
0.68	9.480377E-0005
0.69	8.939819E-0005
0.70	8.437297E-0005
0.71	7.969640E-0005
0.72	7.533980E-0005
0.73	7.127724E-0005
0.74	6.748518E-0005
0.75	6.394227E-0005
0.76	6.062911E-0005
0.77	5.752801E-0005
0.78	5.462288E-0005
0.79	5.189904E-0005
0.80	4.934305E-0005

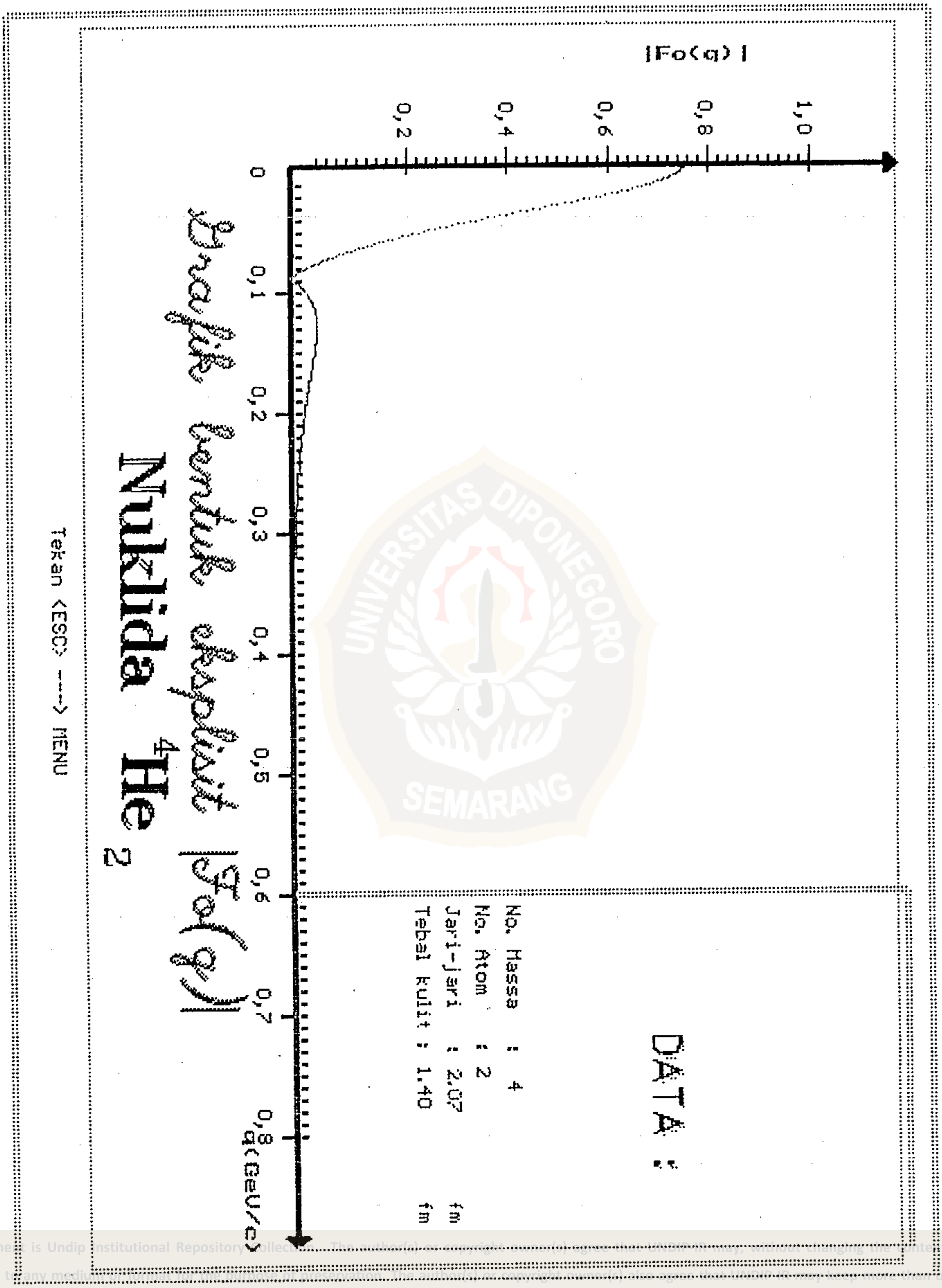
Tabel Perhitungan Numerik
Bentuk eksplisit |Fo(q)|
Untuk nuklida : Bi
Nomor Atom : 83
Nomor Massa : 209
Jari-jari (R) : 6.87
Tebal (t) : 2.10

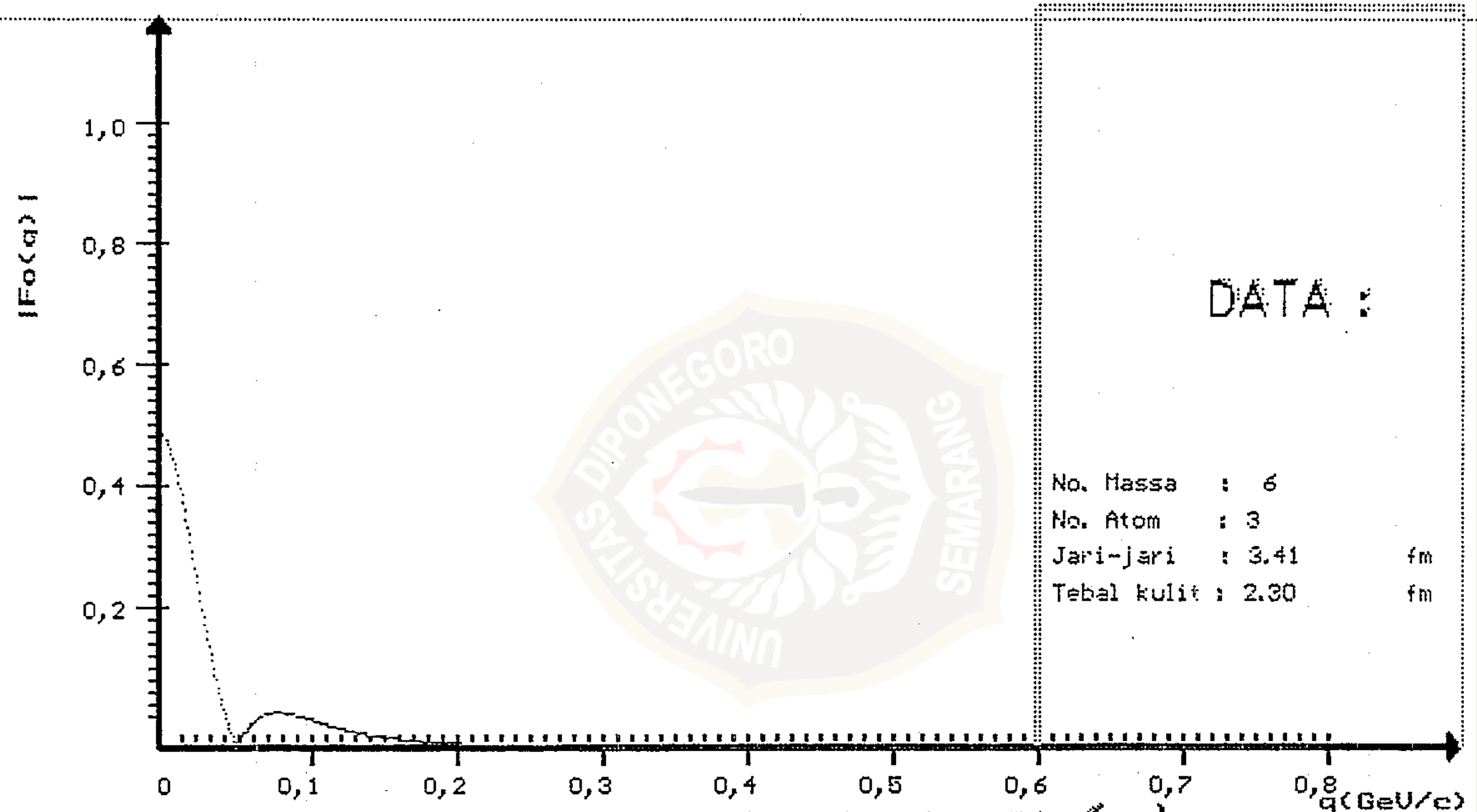
q	|Fo(q)|
0.00	1.079022E+0000
0.01	8.976284E-0001
0.02	5.272434E-0001
0.03	1.576499E-0001
0.04	9.969817E-0002
0.05	2.327071E-0001
0.06	2.760954E-0001
0.07	2.688272E-0001
0.08	2.386848E-0001
0.09	2.017117E-0001
0.10	1.658360E-0001
0.11	1.343014E-0001
0.12	1.079526E-0001
0.13	8.654169E-0002
0.14	6.940894E-0002
0.15	5.580828E-0002
0.16	4.504723E-0002
0.17	3.653535E-0002
0.18	2.979091E-0002
0.19	2.443044E-0002
0.20	2.015286E-0002
0.21	1.672362E-0002
0.22	1.396064E-0002
0.23	1.172269E-0002
0.24	9.900144E-0003
0.25	8.407732E-0003
0.26	7.178936E-0003
0.27	6.161676E-0003
0.28	5.315019E-0003
0.29	4.606652E-0003
0.30	4.010953E-0003
0.31	3.507513E-0003
0.32	3.079998E-0003
0.33	2.715271E-0003
0.34	2.402721E-0003
0.35	2.133732E-0003
0.36	1.901279E-0003
0.37	1.699604E-0003
0.38	1.523971E-0003
0.39	1.370462E-0003
0.40	1.235825E-0003
0.41	1.117349E-0003
0.42	1.012763E-0003

q	|Fo(q)|
0.43	9.201595E-0004
0.44	8.379274E-0004
0.45	7.647028E-0004
0.46	6.993261E-0004
0.47	6.408079E-0004
0.48	5.883012E-0004
0.49	5.410787E-0004
0.50	4.985135E-0004
0.51	4.600642E-0004
0.52	4.252612E-0004
0.53	3.936964E-0004
0.54	3.650141E-0004
0.55	3.389034E-0004
0.56	3.150919E-0004
0.57	2.933404E-0004
0.58	2.734382E-0004
0.59	2.551993E-0004
0.60	2.384594E-0004
0.61	2.230727E-0004
0.62	2.089098E-0004
0.63	1.958555E-0004
0.64	1.838071E-0004
0.65	1.726727E-0004
0.66	1.623704E-0004
0.67	1.528264E-0004
0.68	1.439746E-0004
0.69	1.357556E-0004
0.70	1.281157E-0004
0.71	1.210066E-0004
0.72	1.143846E-0004
0.73	1.082101E-0004
0.74	1.024472E-0004
0.75	9.706341E-0005
0.76	9.202917E-0005
0.77	8.731754E-0005
0.78	8.290399E-0005
0.79	7.876615E-0005
0.80	7.488358E-0005

LAMPIRAN-8

REPRESENTASI GRAFIK HASIL PENGHITUNGAN

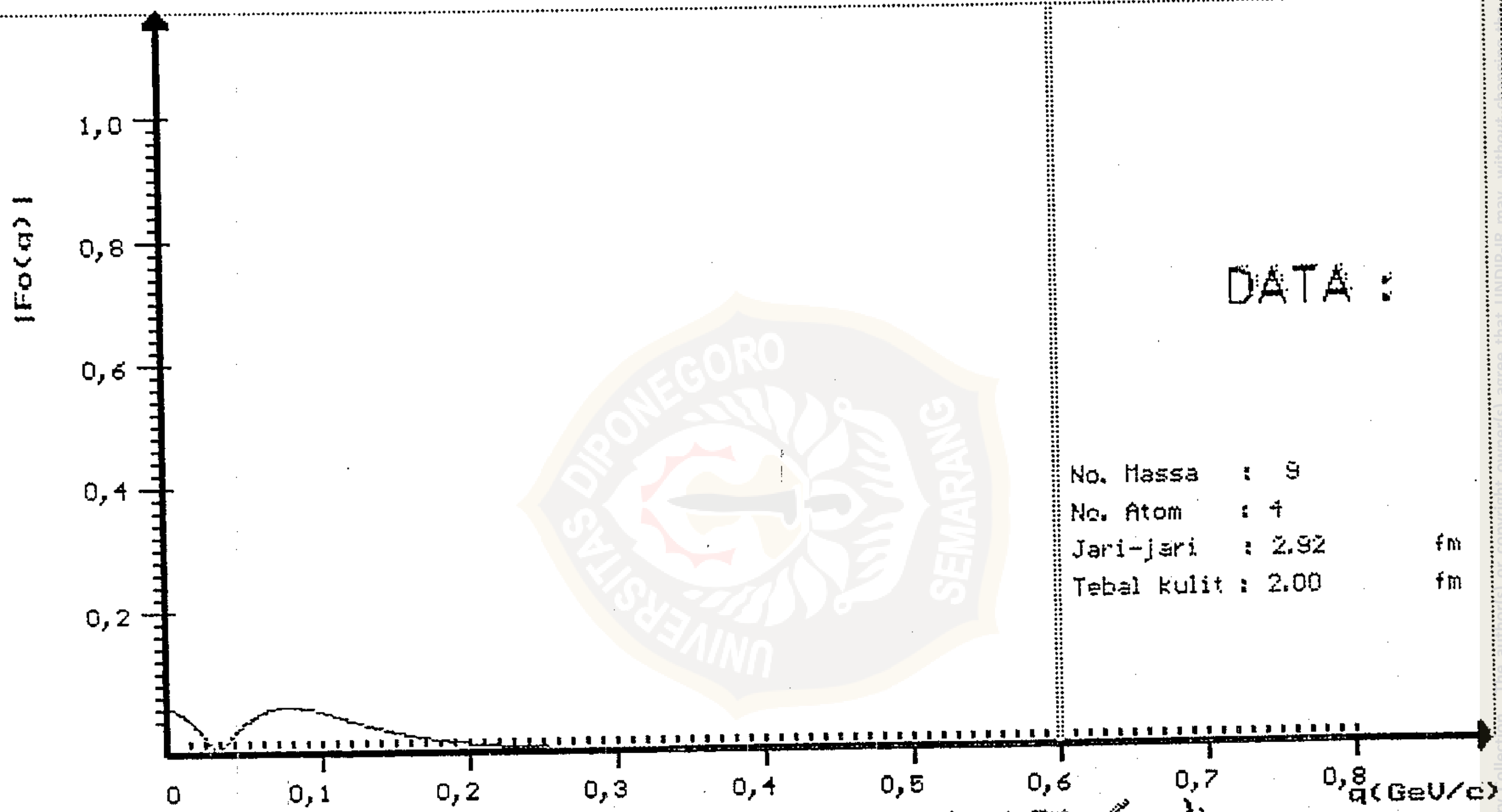




Grafik bentuk eksplisit |Fo(q)|

Nuklida $^{6}Li_{3}$

Tekan <ESC> ---> MENU



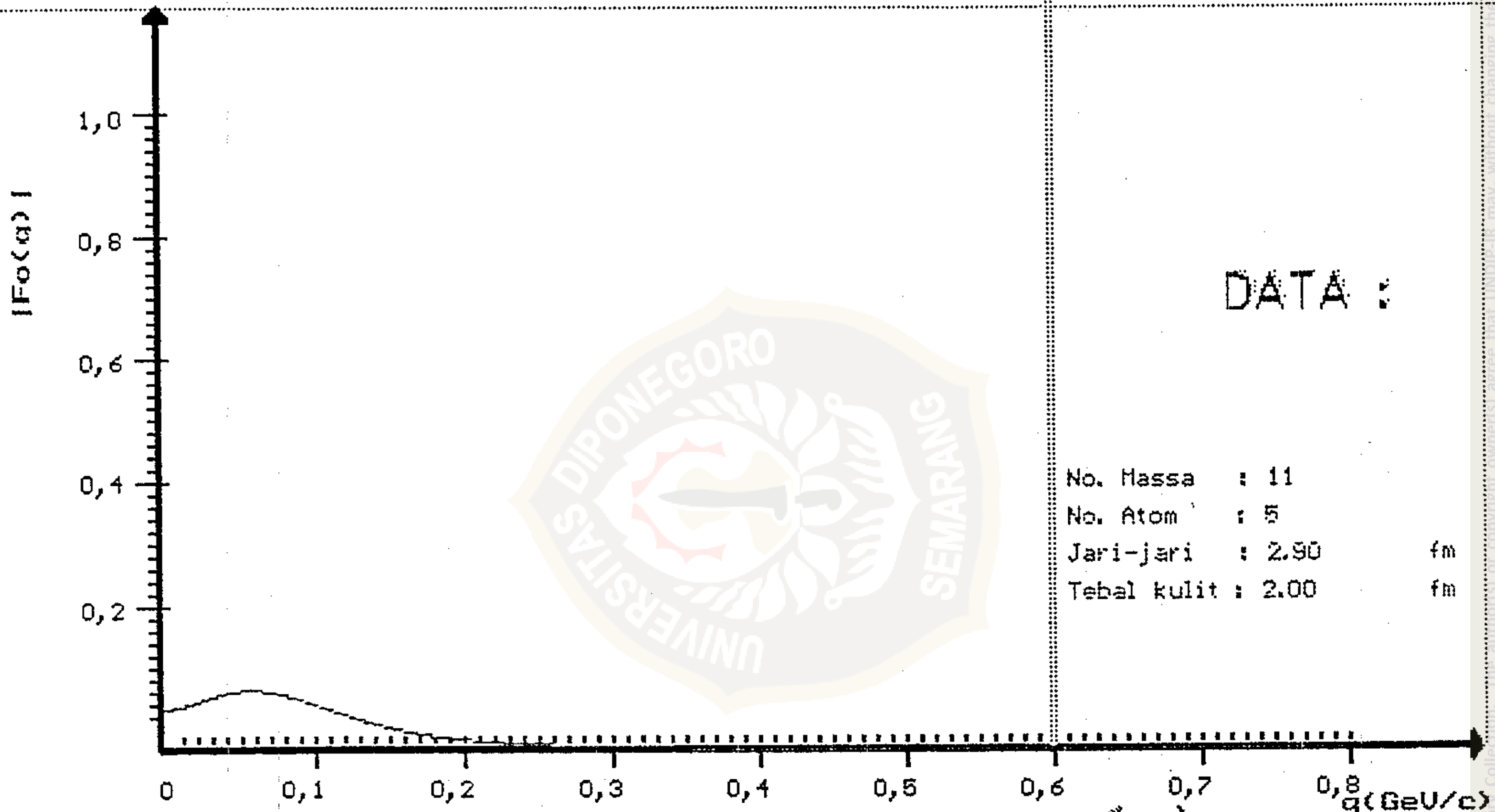
DATA :

No. Massa : 9
No. Atom : 4
Jari-jari : 2.92 fm
Tebal kulit : 2.00 fm

Grafik bentuk eksplisit |Fo(q)|

Nuklida $^{9}Be_{4}$

Tekan <ESC> ---> MENU



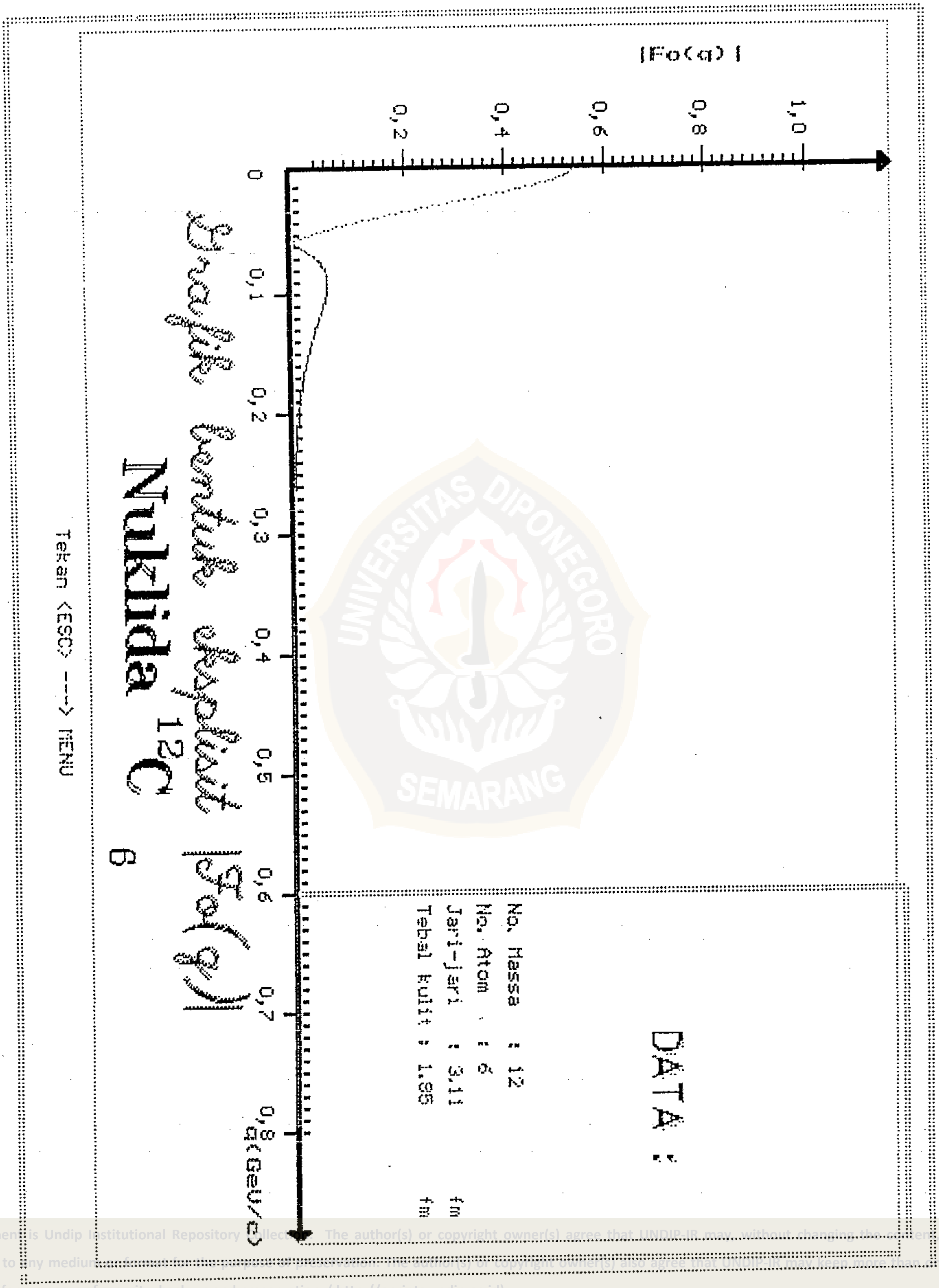
DATA :

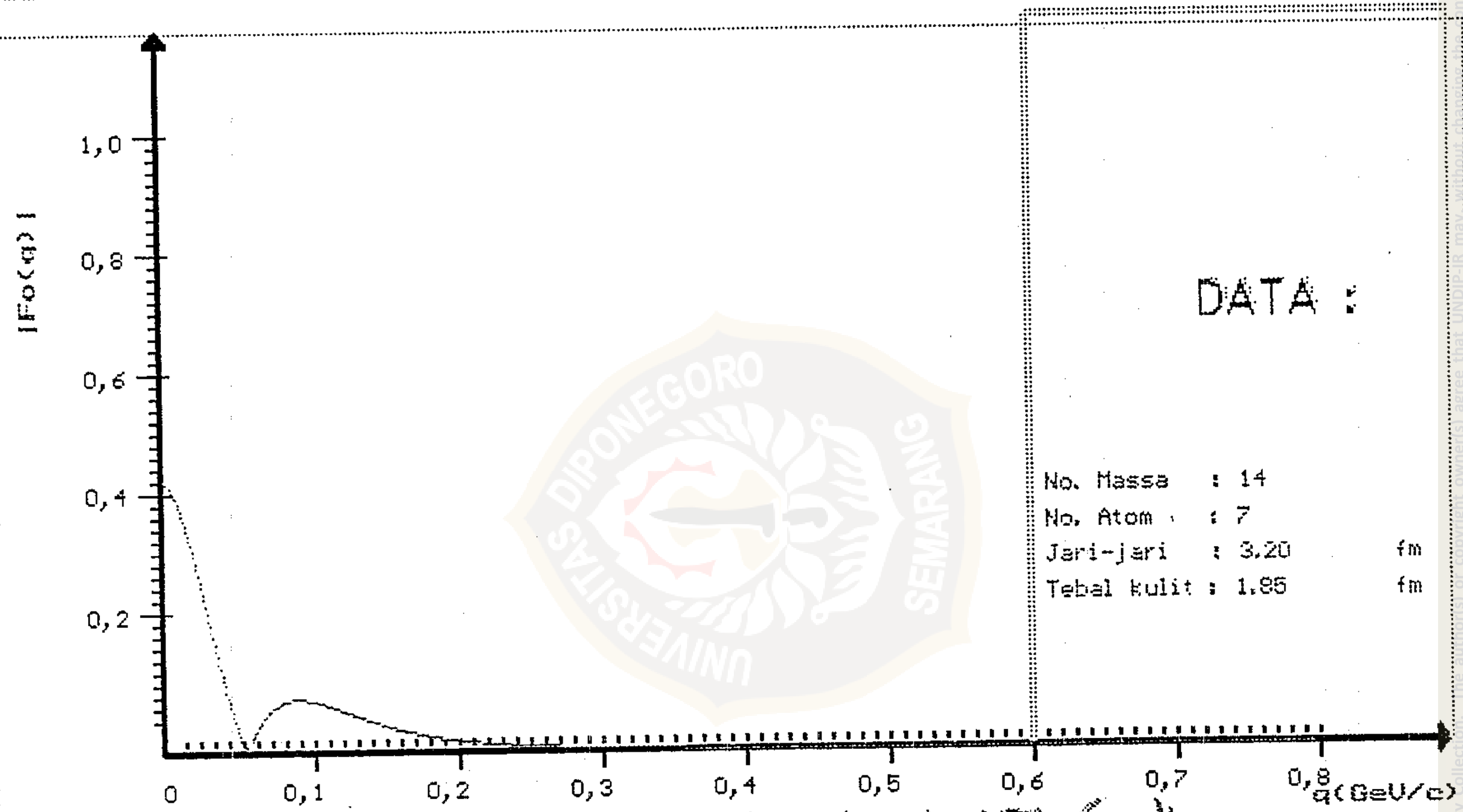
No. Massa : 11
No. Atom : 5
Jari-jari : 2.90 fm
Tebal kulit : 2.00 fm

Grafik bentuk eksplisit |Fo(q)|

Nuklida $^{11}_{5}B$

Tekan <ESC> ---> MENU

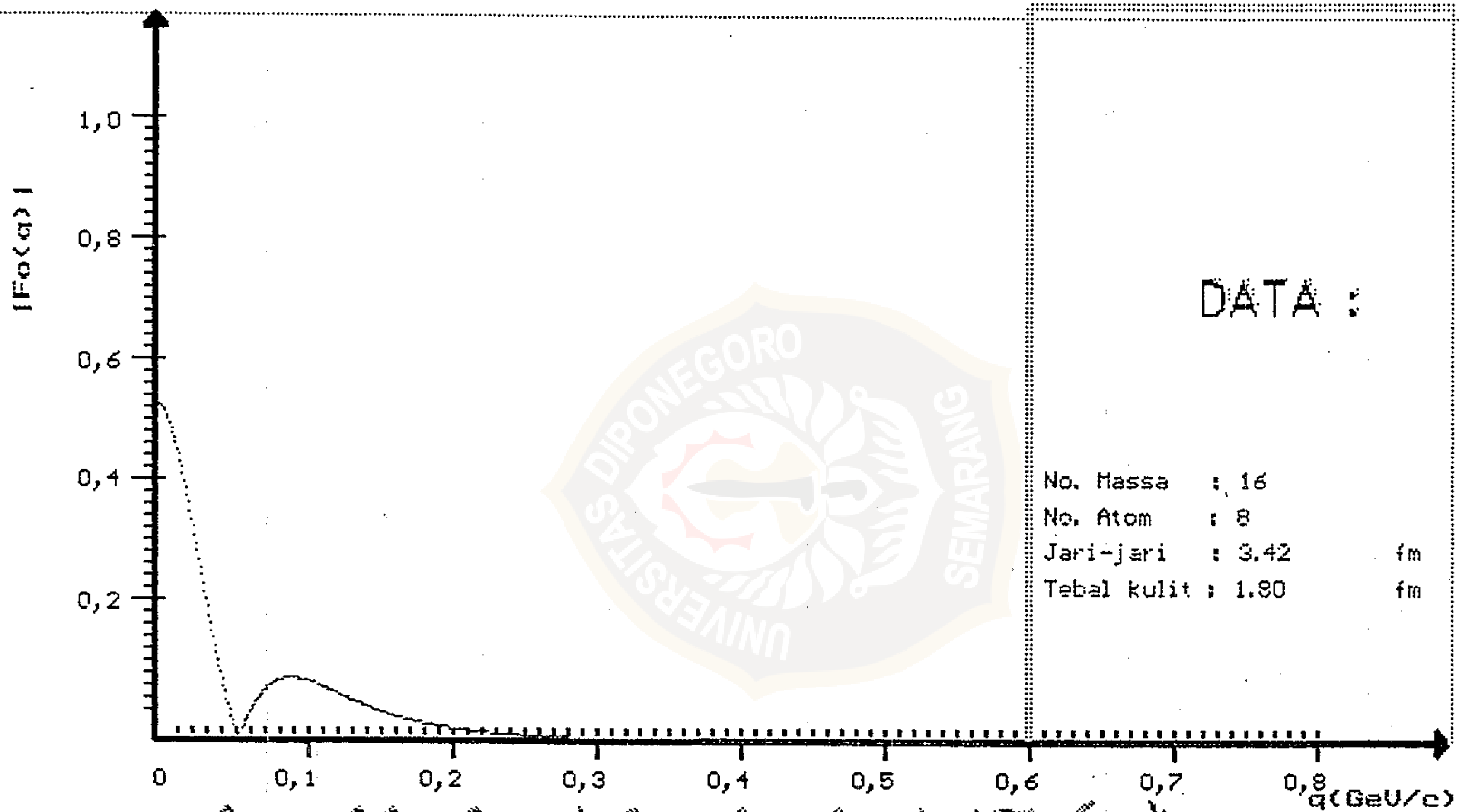

|Fo(q)|
0,2
0,4
0,6
0,8
1,0
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
q(GeV/c)
DATA :
No. Massa : 12
No. Atom : 6
Jari-jari : 3,11 fm
Tebal kulit : 1,85 fm
Grafik bentuk absolut |Fo(q)|
Nuklida ¹²₆C
Tekan <ESC> ---> MENU



Grafik bentuk eksplisit $|F_o(q)|$

Nuklida $^{14}_{7}N$

Tekan <ESC> ---> MENU



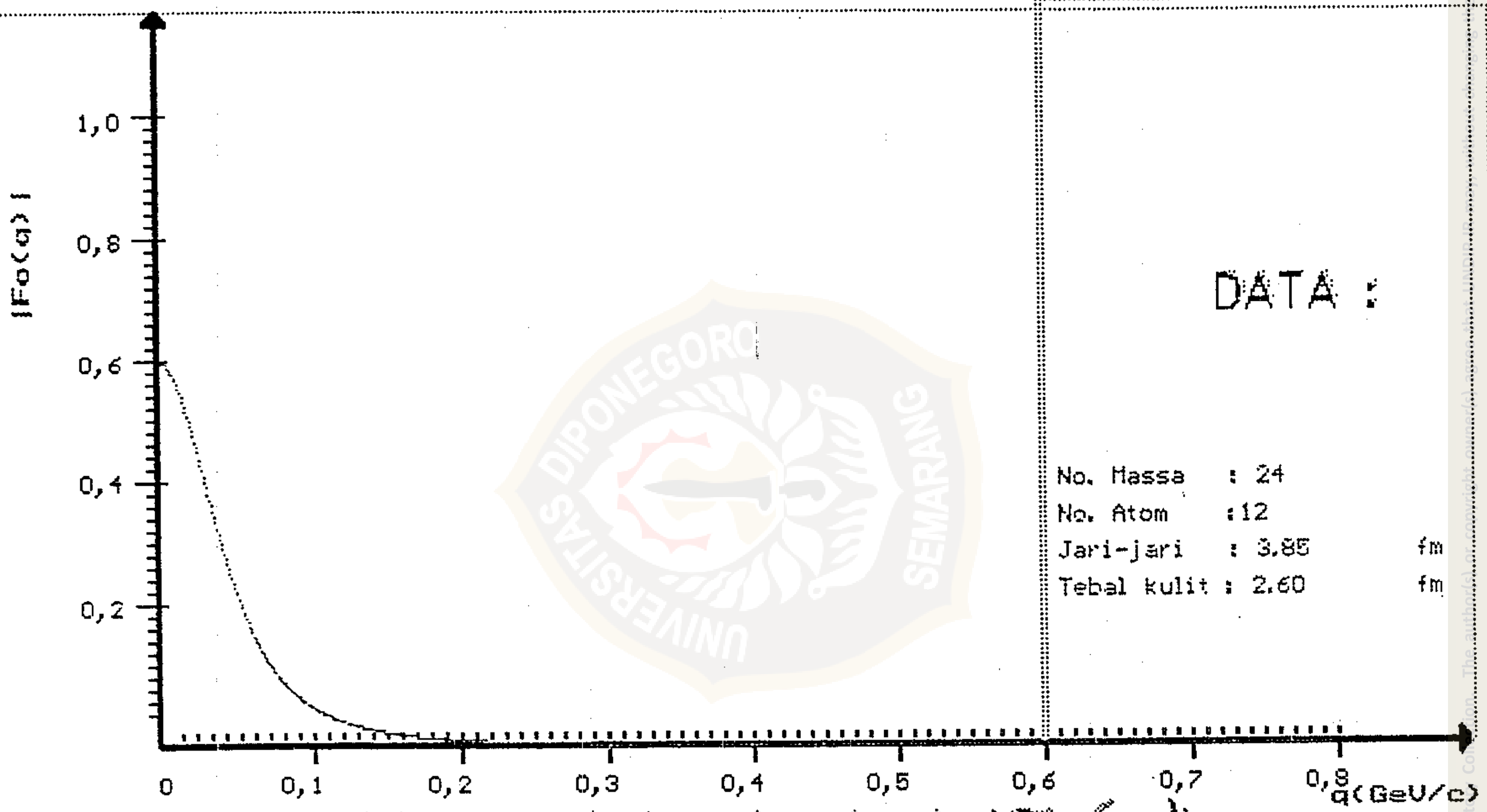
DATA :

No. Massa : 16
No. Atom : 8
Jari-jari : 3.42 fm
Tebal kulit : 1.80 fm

Grafik bentuk eksplisit |Fo(q)|

Nuklida $^{16}O_{8}$

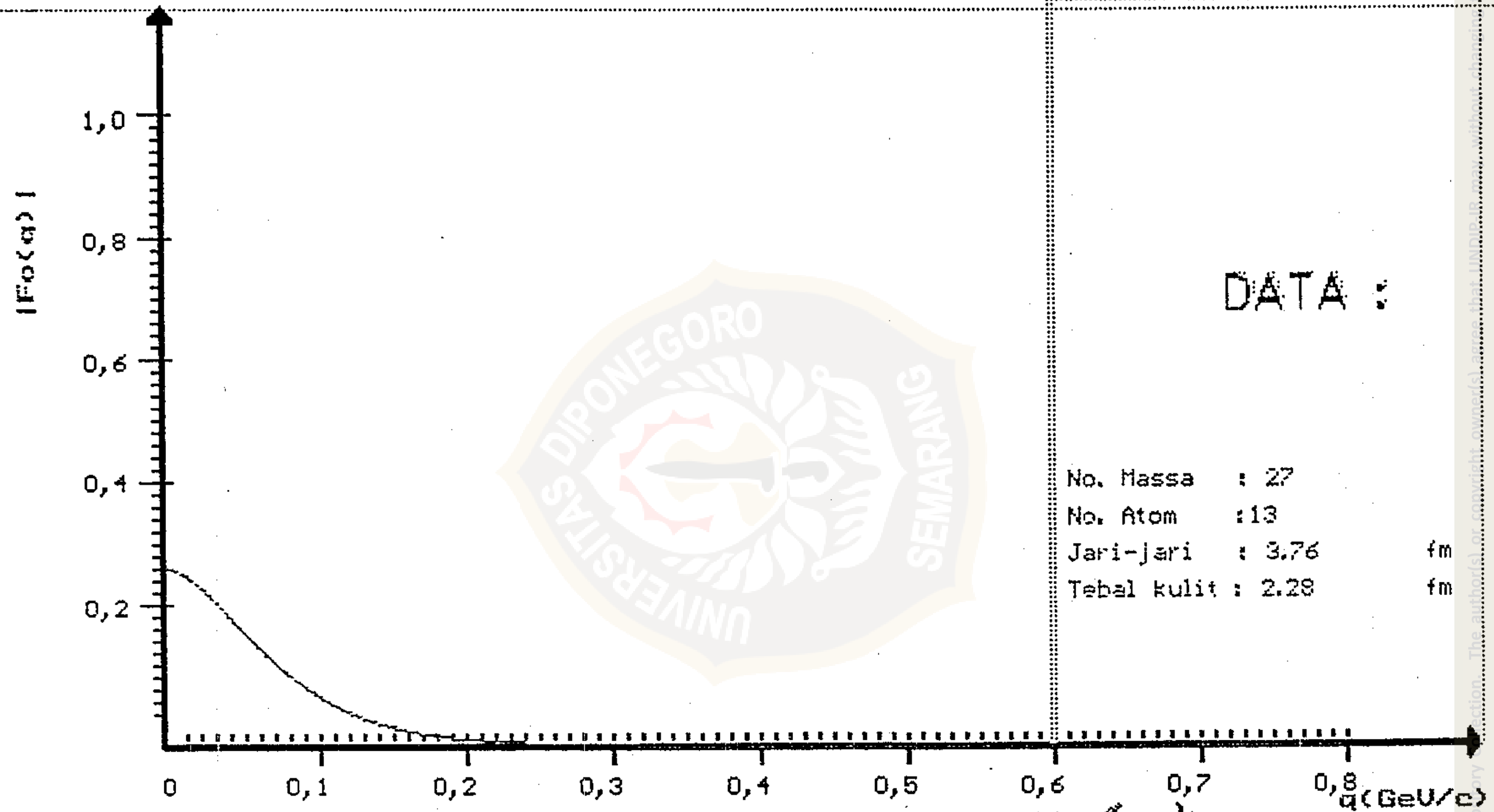
Tekan <ESC> ---> MENU



Grafik bentuk eksplisit $|Fo(q)|$

Nuklida $^{24}Mg_{12}$

Tekan <ESC> ---> MENU



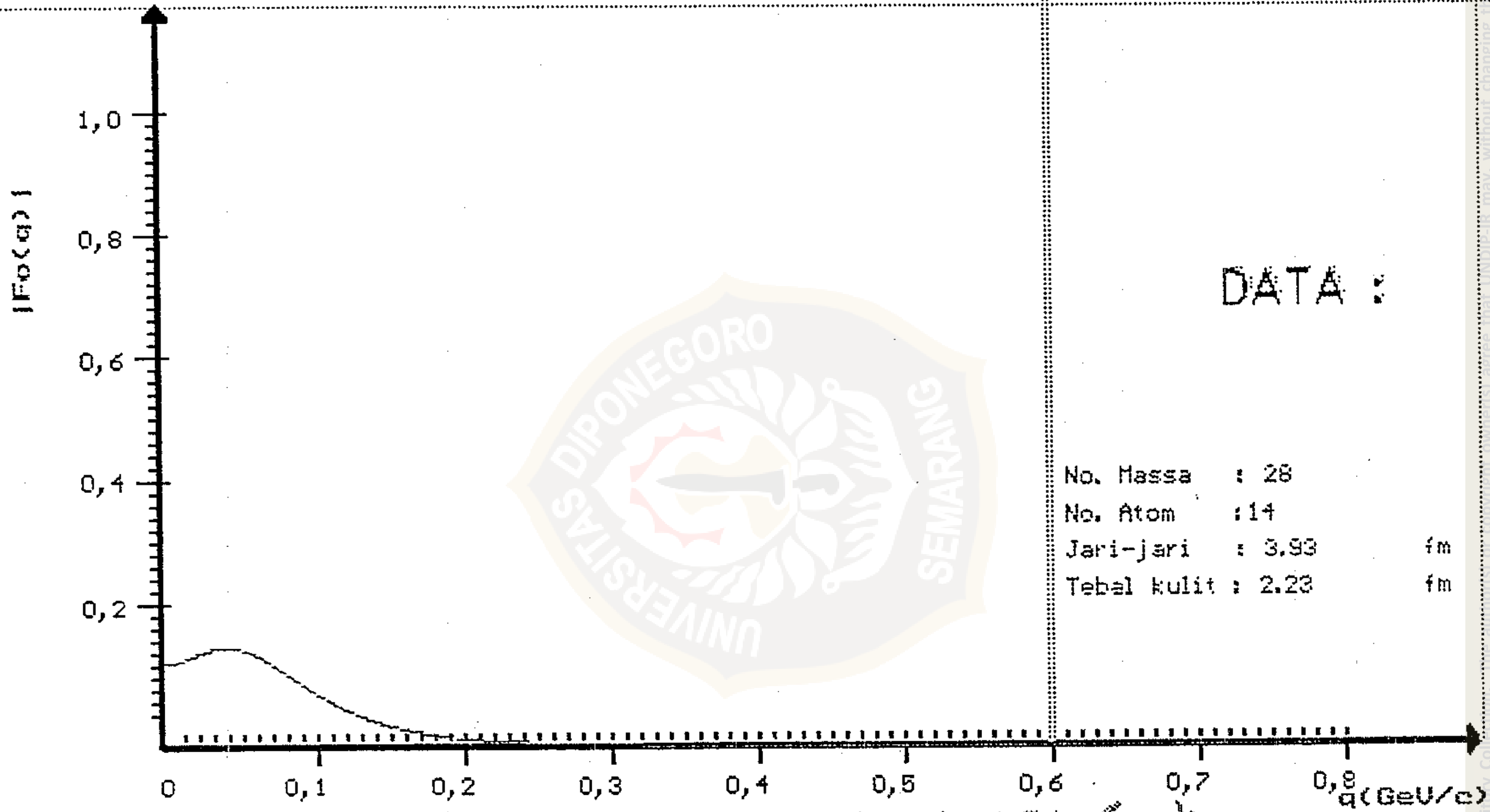
DATA :

No. Massa : 27
No. Atom :13
Jari-jari : 3.76 fm
Tebal kulit : 2.28 fm

Grafik bentuk eksplisit |Fo(q)|

Nuklida $^{27}Al_{13}$

Tekan <ESC> ---> MENU



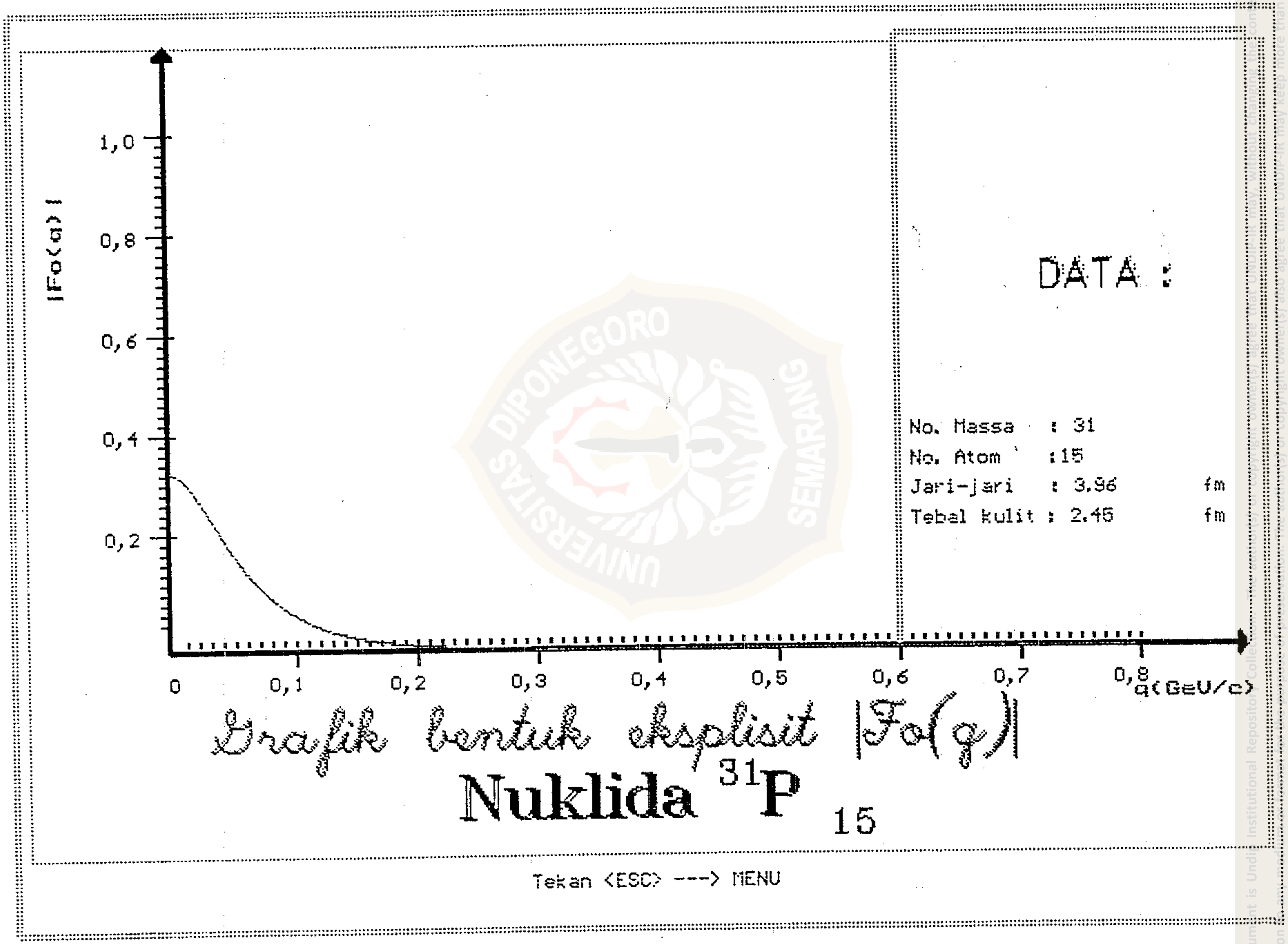
DATA :

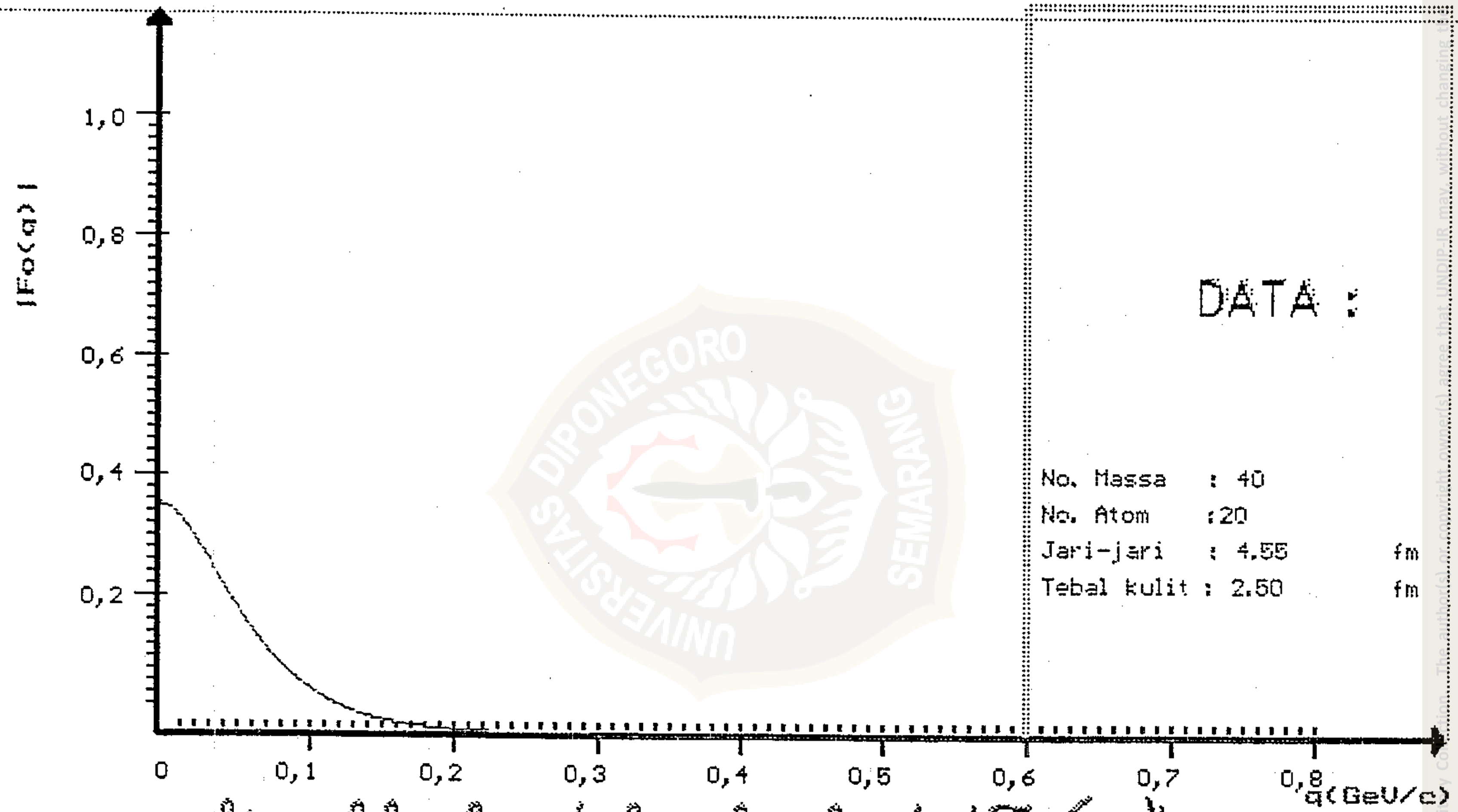
No. Massa : 28
No. Atom : 14
Jari-jari : 3.93 fm
Tebal kulit : 2.23 fm

Grafik bentuk eksplisit |Fo(q)|

Nuklida $^{28}Si_{14}$

Tekan <ESC> ---> MENU

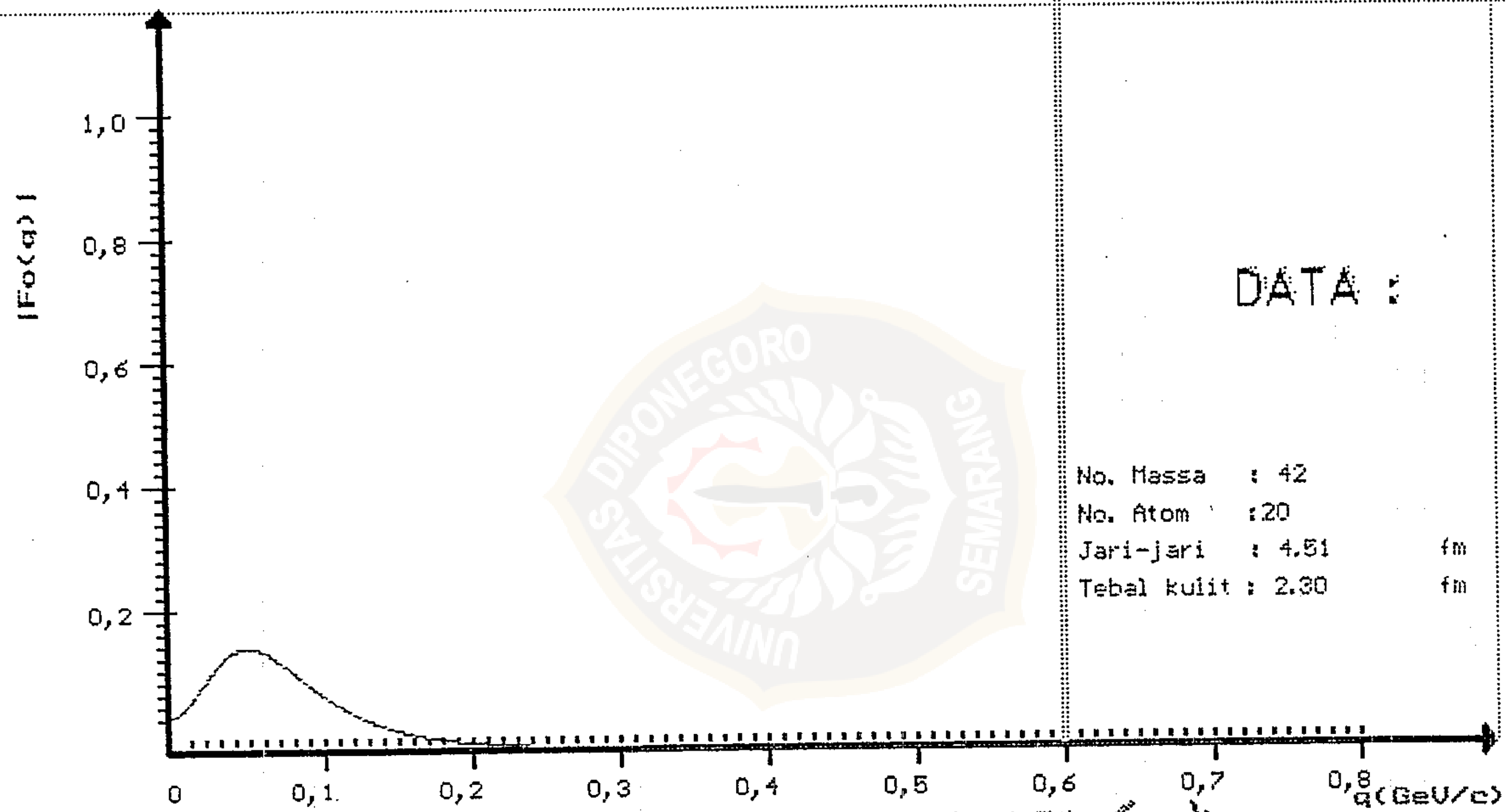

|Fo(q)|
1,0
0,8
0,6
0,4
0,2
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
q(GeV/c)
DATA :
No. Massa : 31
No. Atom :15
Jari-jari : 3.96 fm
Tebal kulit : 2.45 fm
Grafik bentuk eksplisit |Fo(q)|
Nuklida 31P 15
Tekan <ESC> ---> MENU



Grafik bentuk eksplisit |Fo(q)|

Nuklida $^{40}Ca_{20}$

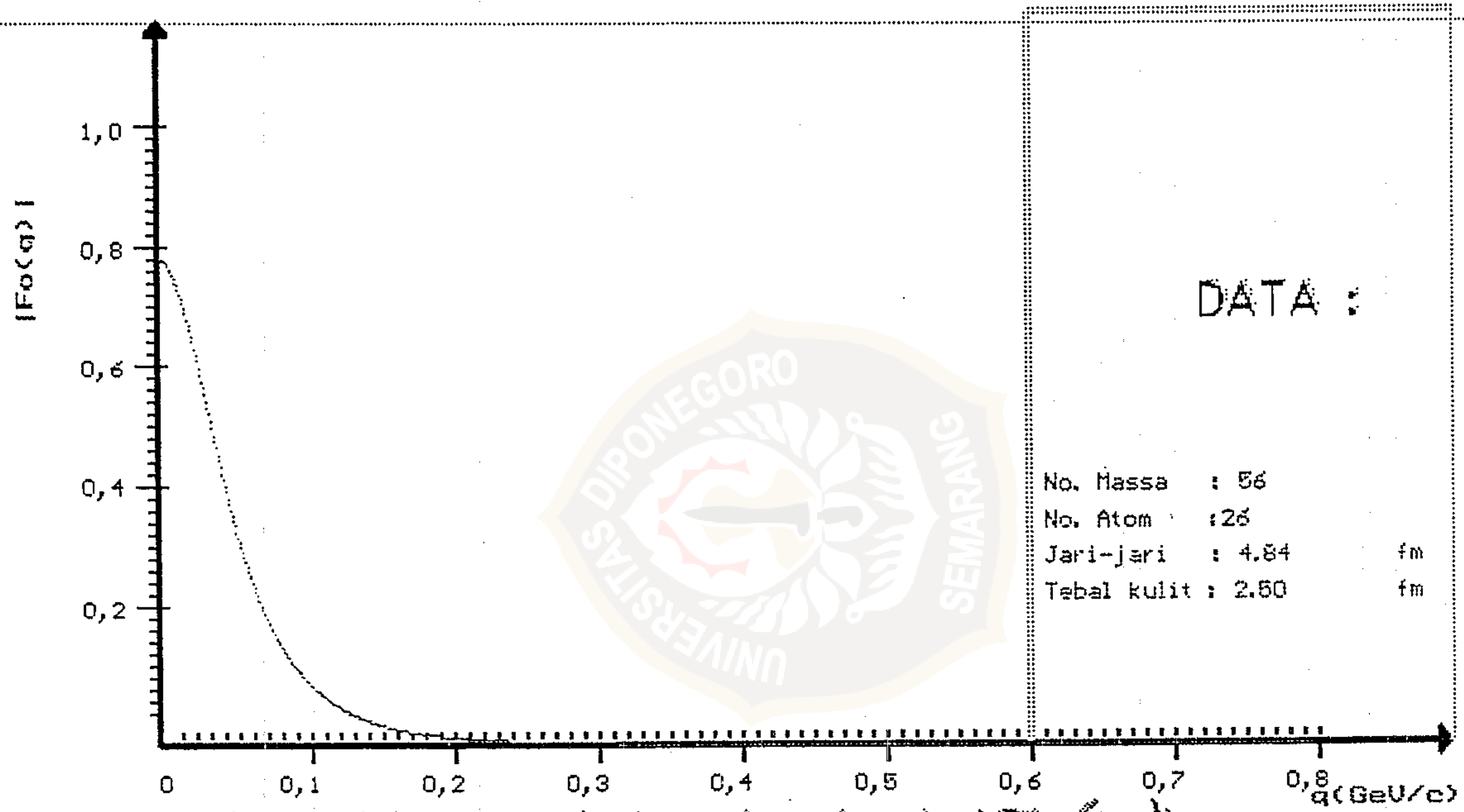
Tekan <ESC> ---> MENU



Grafik bentuk eksplisit $|Fo(q)|$

Nuklida $^{42}Ca_{20}$

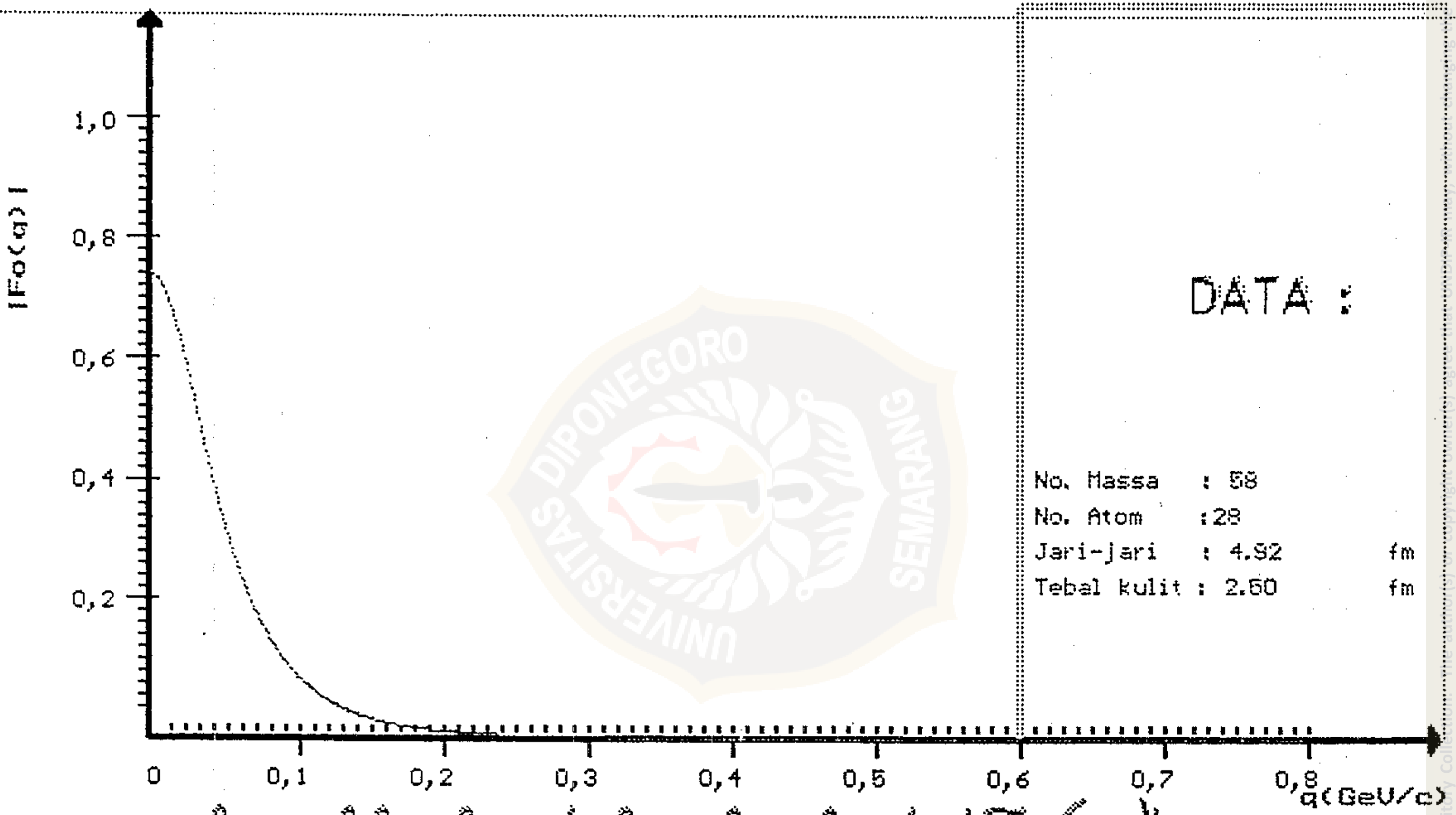
Tekan <ESC> ---> MENU



Grafik bentuk eksplisit |Fo(q)|

Nuklida $^{56}Fe_{26}$

Tekan <ESC> ---> MENU



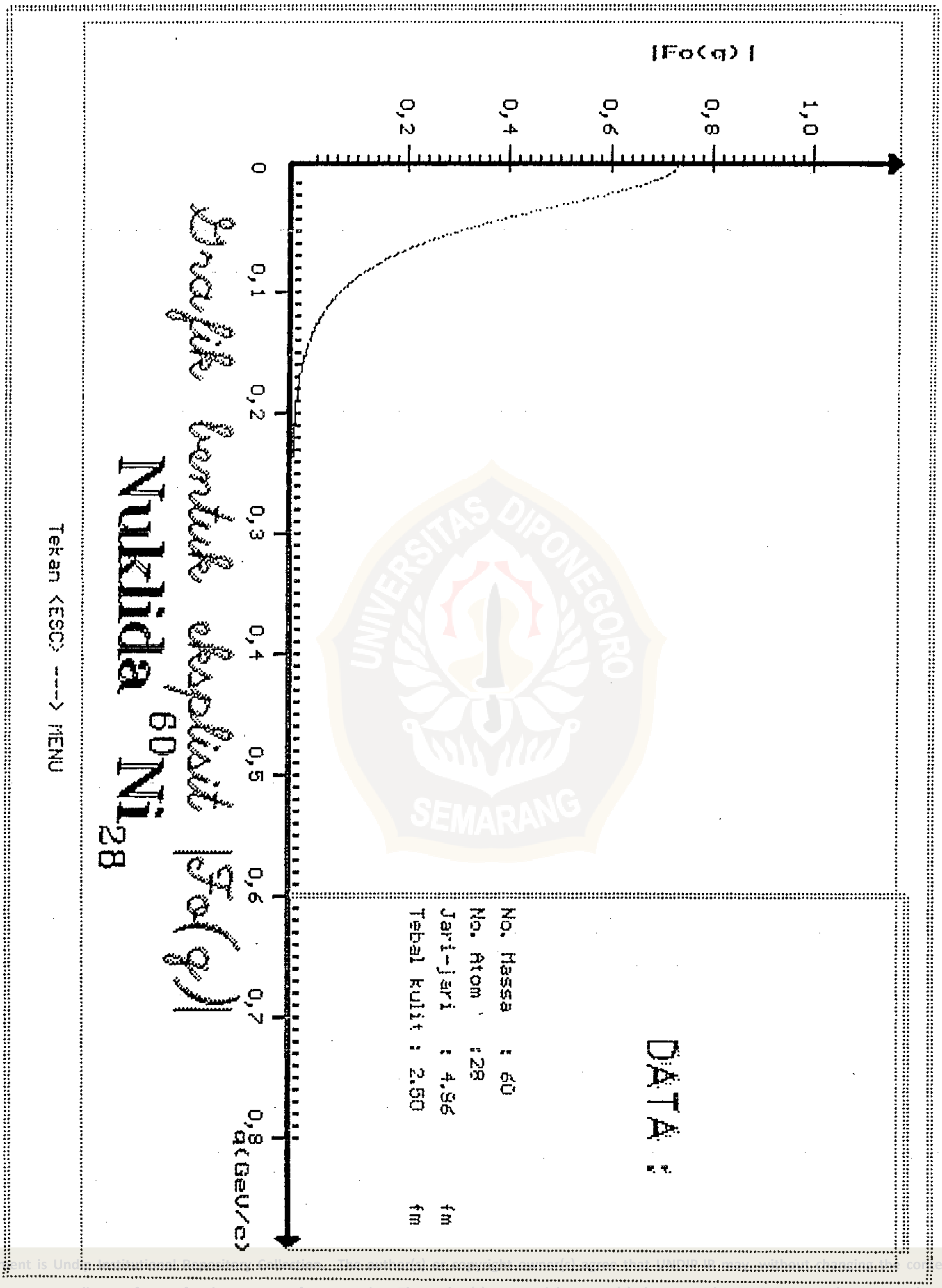
DATA :

No. Massa : 58
No. Atom :28
Jari-jari : 4.92 fm
Tebal kulit : 2.60 fm

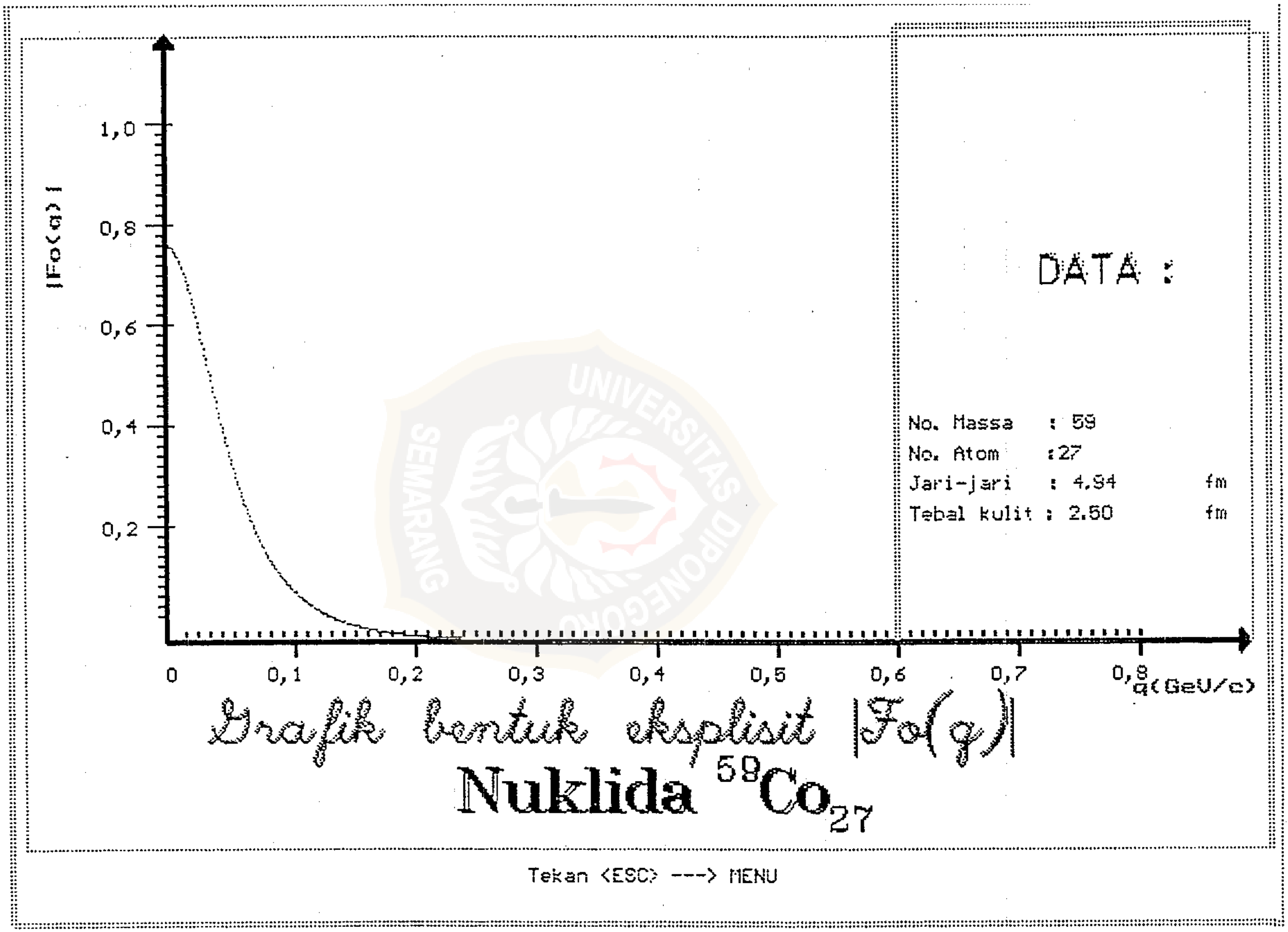
Grafik bentuk eksplisit |Fo(q)|

Nuklida $^{58}Ni_{28}$

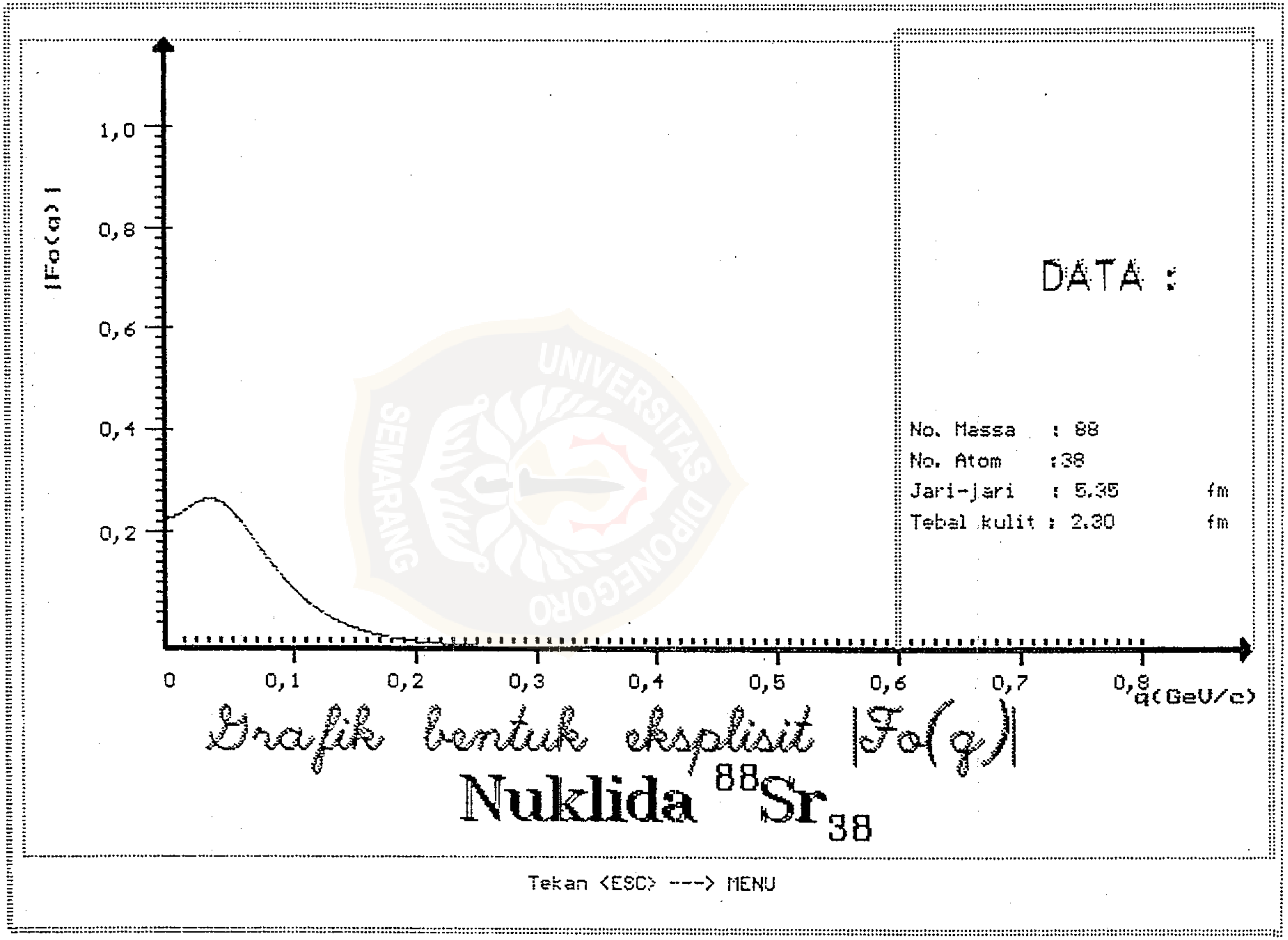
Tekan <ESC> ---> MENU


|Fo(q)|
0,2
0,4
0,6
0,8
1,0
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
q(GeV/c)
Grafik bentuk eksplisit |Fo(q)|
Nuklida $^{60}Ni_{28}$
DATA :
No. Massa : 60
No. Atom : 28
Jari-jari : 4.86 fm
Tebal Kulit : 2.50 fm
Tekan <ESC> ---> MENU

L.8.18

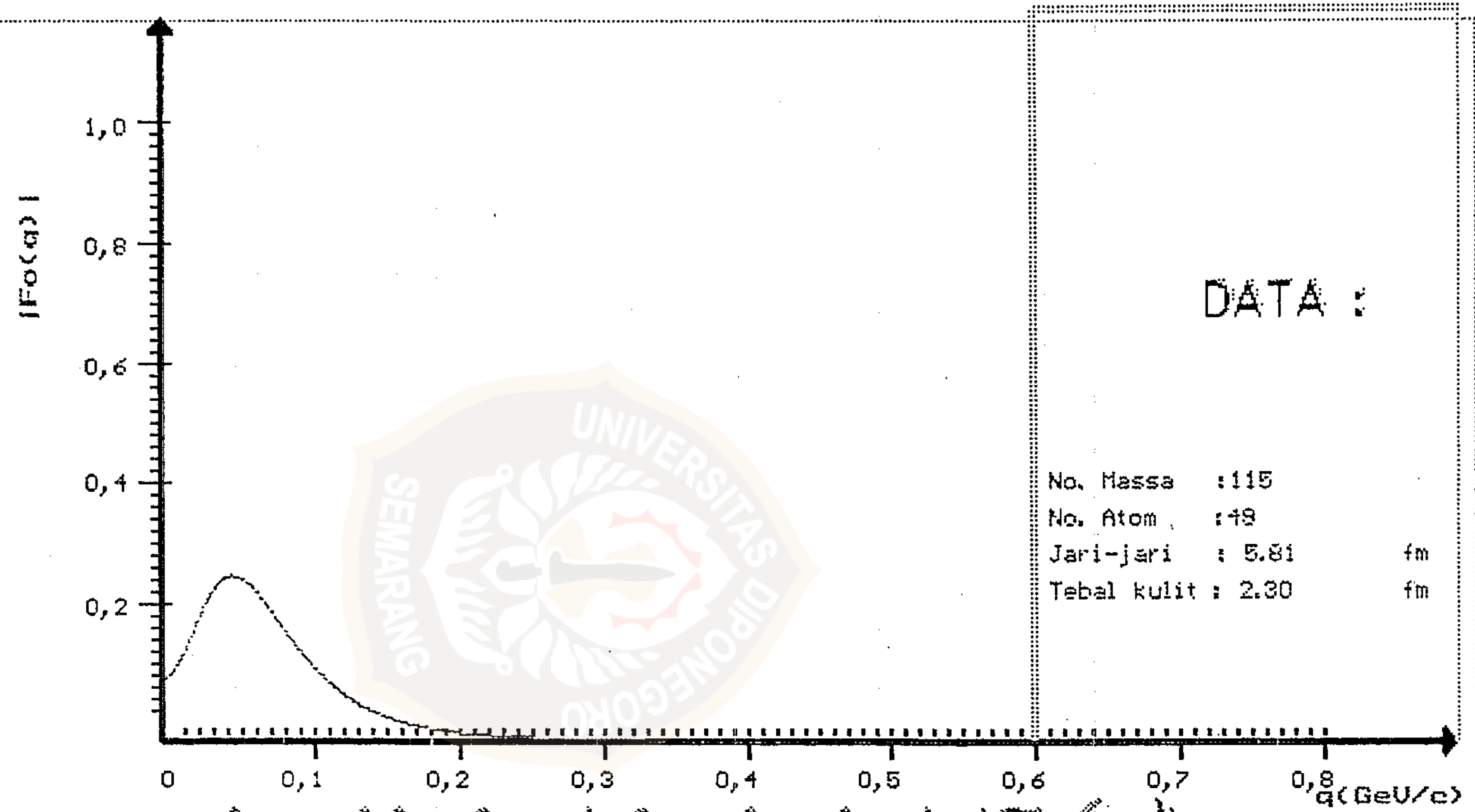


|Fo(q)|
1,0
0,8
0,6
0,4
0,2
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
q(GeV/c)
DATA :
No. Massa : 59
No. Atom :27
Jari-jari : 4.94 fm
Tebal kulit : 2.50 fm
Grafik bentuk eksplisit |Fo(q)|
Nuklida 59Co27
Tekan <ESC> ---> MENU



|Fo(q)|
1,0
0,8
0,6
0,4
0,2
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
q(GeV/c)
DATA :
No. Massa : 88
No. Atom :38
Jari-jari : 5.35 fm
Tebal kulit : 2.30 fm
Grafik bentuk eksplisit |Fo(q)|
Nuklida 88Sr38
Tekan <ESC> ---> MENU

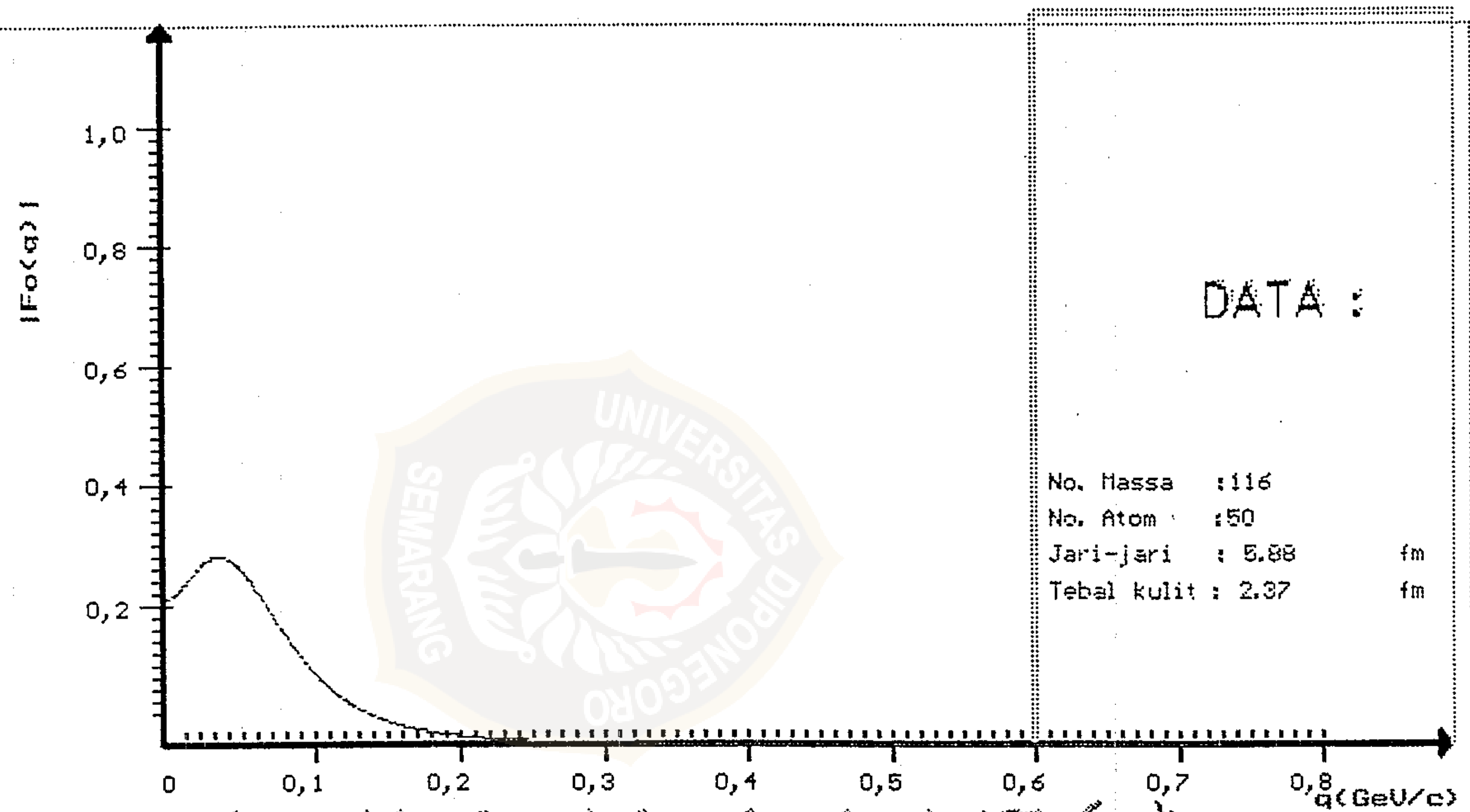
L.8.20



Grafik bentuk eksplisit |Fo(q)|

Nuklida $^{115}In_{49}$

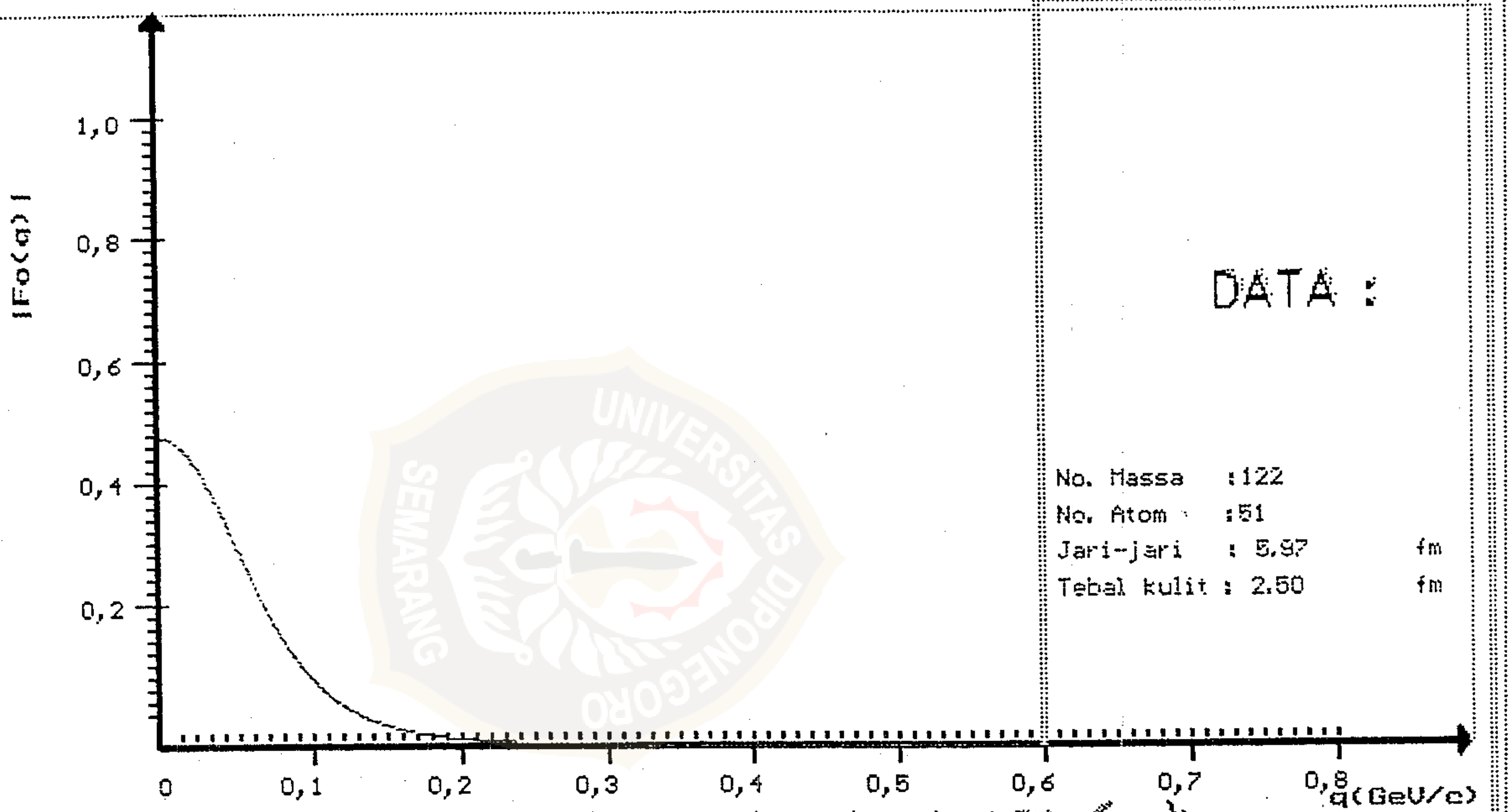
Tekan <ESC> ---> MENU



Grafik bentuk eksplisit |Fo(q)|

Nuklida $^{116}Sn_{50}$

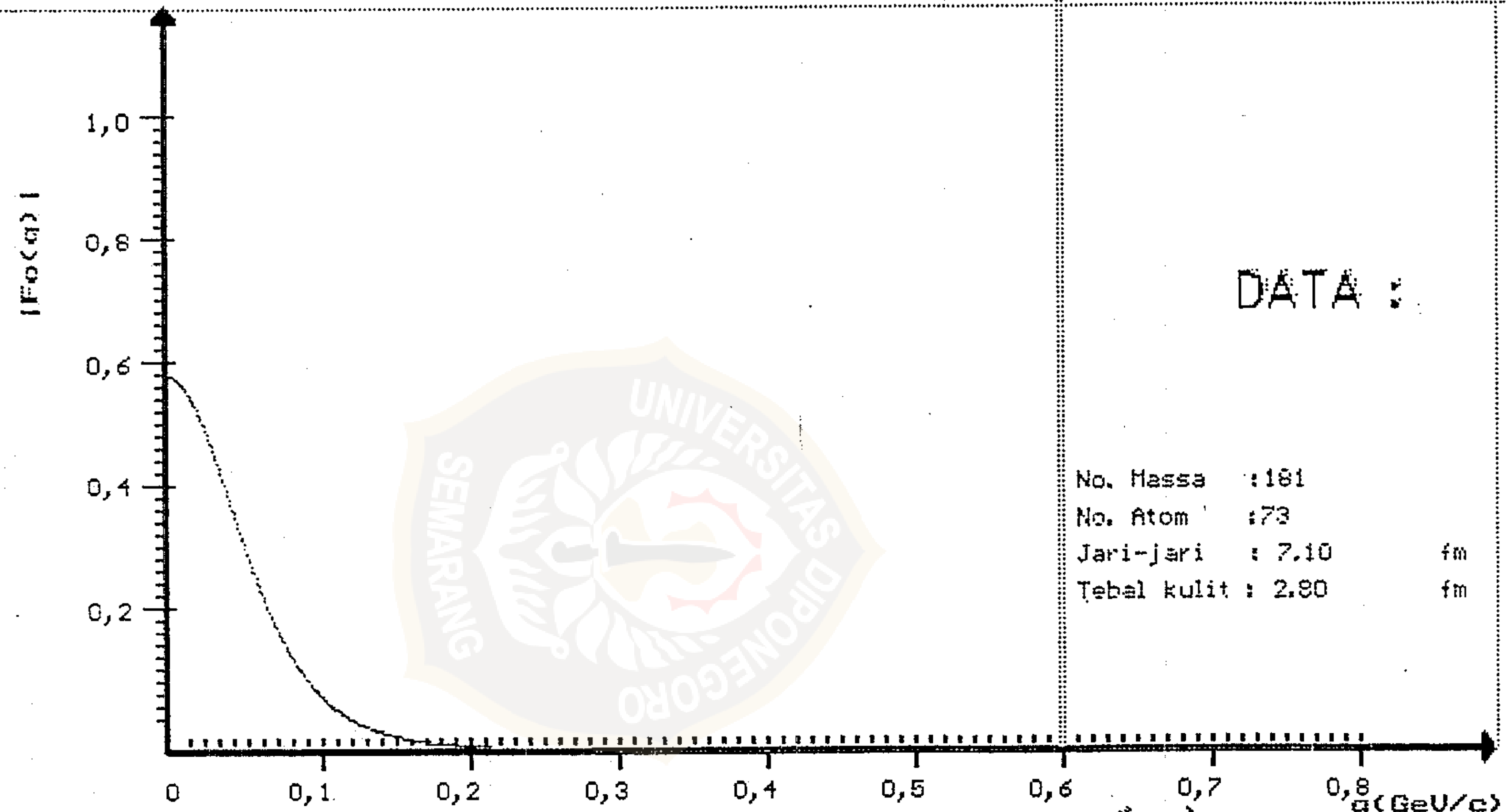
Tekan <ESC> ---> MENU



Grafik bentuk eksplisit $|Fo(q)|$

Nuklida $^{122}Sb_{51}$

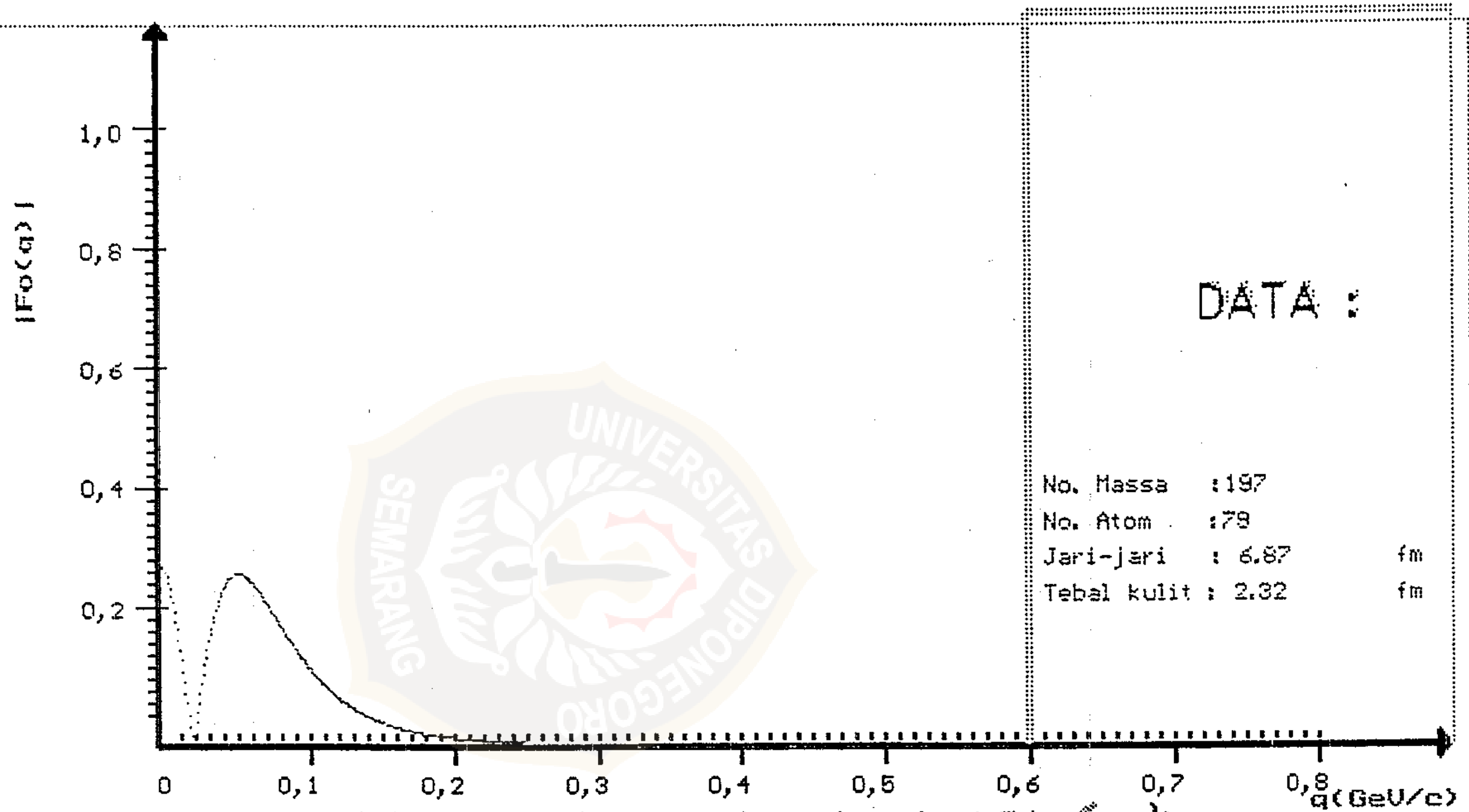
Tekan <ESC> ---> MENU



Grafik bentuk eksplisit |Fo(q)|

Nuklida $^{181}Ta_{73}$

Tekan <ESC> ---> MENU

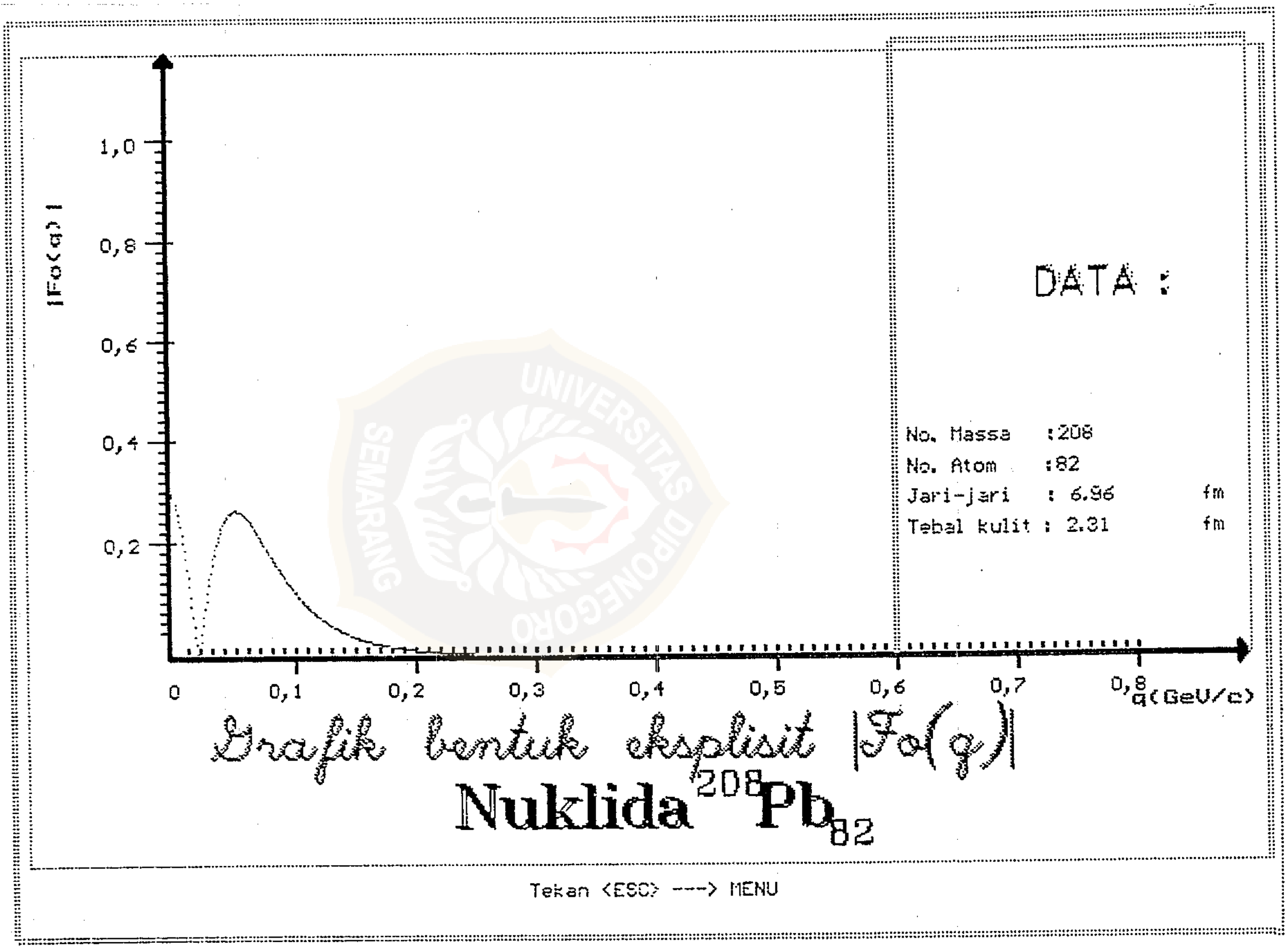


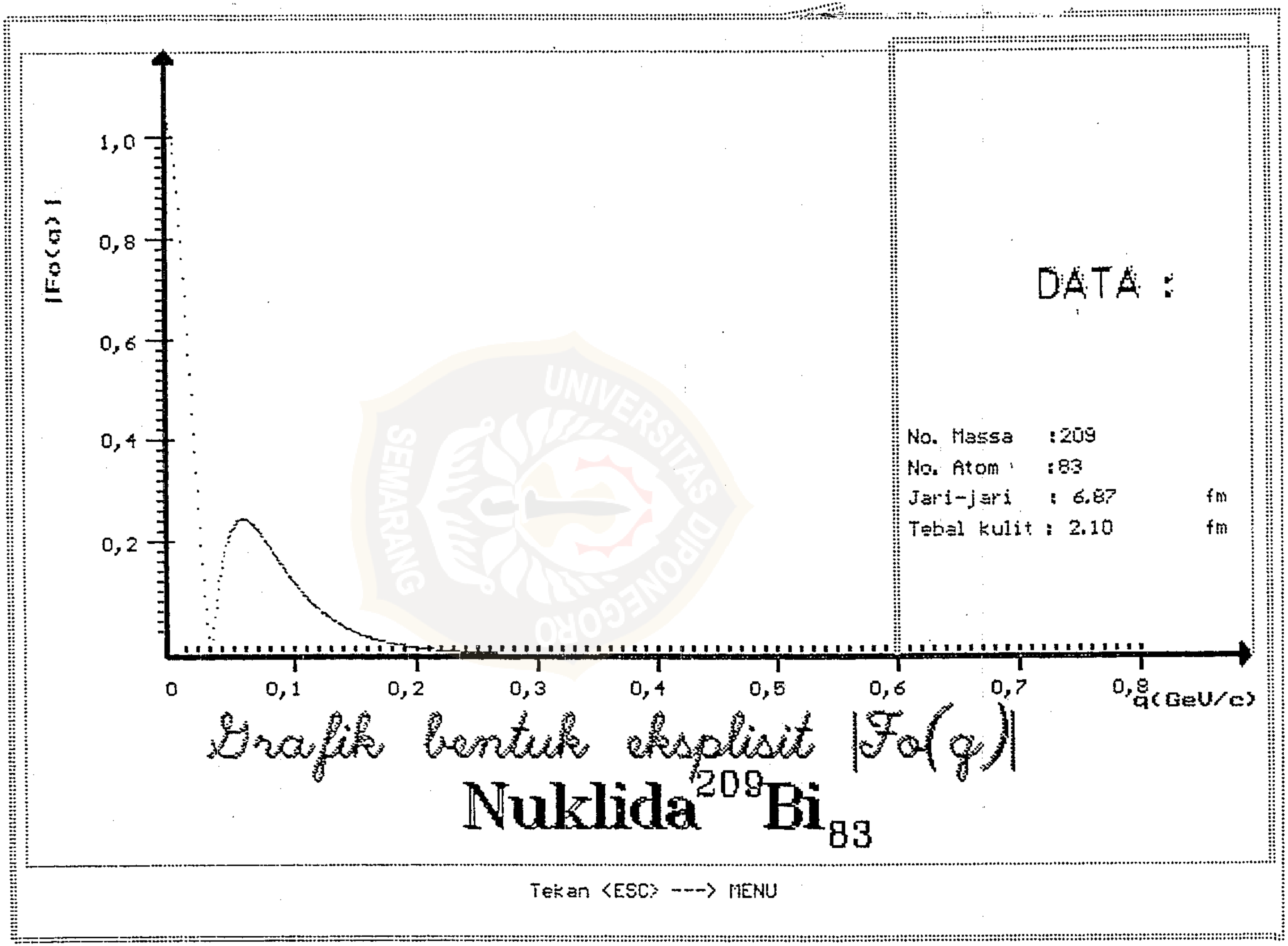
Grafik bentuk eksplisit |Fo(q)|

Nuklida $^{197}An_{79}$

Tekan <ESC> ---> MENU

L.8.25


|Fo(q)|
1,0
0,8
0,6
0,4
0,2
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
q(GeV/c)
DATA :
No. Massa :208
No. Atom :82
Jari-jari : 6.96 fm
Tebal kulit : 2.31 fm
Grafik bentuk eksplisit |Fo(q)|
Nuklida 208 Pb 82
Tekan <ESC> ---> MENU


|Fo(q)|
1,0
0,8
0,6
0,4
0,2
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
q(GeV/c)
DATA :
No. Massa :209
No. Atom :83
Jari-jari : 6.87 fm
Tebal kulit : 2.10 fm
Grafik bentuk eksplisit |Fo(q)|
Nuklida 209Bi83
Tekan <ESC> ---> MENU