作业3. 杨雨函. 2020011267

(1). 聚变反应功率密度: $S_f = E_f n_1 n_2 \langle \sigma v \rangle = E_f \dfrac{n^2}{4} \langle \sigma v \rangle$.

$E_f = 17.6\,\text{MeV}.\quad n = 10^{20}\,m^{-3} \quad \langle \sigma v \rangle = 1.135 \times 10^{-22}\,m^3/s.$

$\rightarrow S_f = 4.994 \times 10^{18}\,\text{MeV}\cdot m^{-3}\cdot s^{-1} = 0.8\,\text{MW}m^{-3}.$

轫致辐射功率: $S_B = \left(\dfrac{2^{1/2}}{3\pi^{5/2}}\right)\left(\dfrac{e^6}{\varepsilon_0^3 c^3 h m_e^{3/2}}\right) Z_{eff}\, n_e^2\, T_e^{1/2} \quad W/m^3$

$= 1.625 \times 10^{-38} Z_{eff}\, n_e^2 \sqrt{T_e[eV]} \quad W/m^3.$

$Z_{eff} = \dfrac{\sum z_j^2 n_j}{n_e}.\quad T = 10^4\,eV.$

$\rightarrow S_B = 1.625 \times 10^4\,W/m^3$

回旋辐射功率: $S_c = \dfrac{e^4}{3\pi\varepsilon_0 m_e^3 c^3} B^2 n_e T_e$

$= 6.21 \times 10^{20} B^2 n_e T_e[eV]$

$B = 6T.\quad T = 10^4\,eV.$

$\rightarrow S_c \approx 2.24 \times 10^6\,W/m^3.$

(2). S_f: $E_f = 18.3\,\text{MeV}.\quad \langle \sigma v \rangle = 2.223 \times 10^{-25}\,m^3/s.$

$\rightarrow S_f = 1.017 \times 10^{16}\,\text{MeV}\cdot m^{-3}\cdot s^{-1} \approx 0.00163\,\text{MW}m^{-3}.$

S_B: $T = 100\,keV = 10^5\,eV \quad . \; Z_{eff} = 4.$

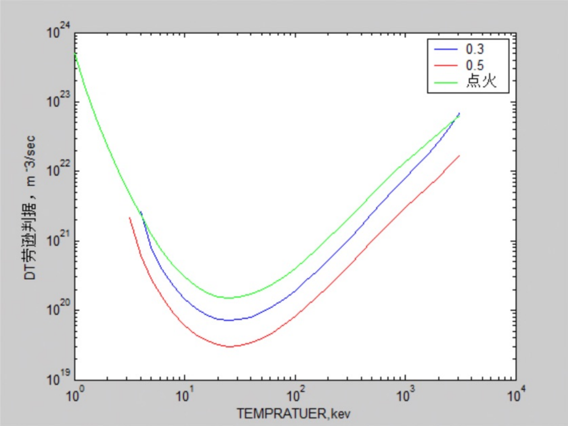
$\rightarrow S_B \approx 2.06 \times 10^5\,W/m^3.$

S_c: $T = 10^5\,eV.$

$\rightarrow S_c \approx 2.24 \times 10^7\,W/m^3.$

作业4. 杨雨涵. 2020011219.

1.



点火条件仍为 $\eta=0.2$ 时的劳逊判据.

2. $n\tau_E \geq \dfrac{3T}{\frac{k}{4}\langle\sigma v\rangle E_f - \frac{S_B}{n^2}}$, $k=\frac{5}{8}$, $T\approx 300\,\mathrm{keV}$. $\langle\sigma v\rangle \approx 1.403\times10^{-22}\,m^3/s$.

不增殖: $E_f = 3.65\,\mathrm{MeV}$. $\dfrac{S_B}{n^2} = 1.625\times10^{-38}\cdot\sqrt{3\times10^5}\,/\,1.6\times10^{-13} \approx 5.56\times10^{-23}\,\mathrm{MeV}$

$\Rightarrow n\tau_E \geq 3.7\times10^{22}\,m^{-3}s$

增殖: $E_f = 43.2\,\mathrm{MeV}$.

$\rightarrow n\tau_E \geq 1\times10^{21}\,m^{-3}s$

3. $Q_E = \dfrac{P_{out}^{(E)} - P_{in}^{(E)}}{P_{in}^{(E)}}$, $P_{in}^{(E)} = \dfrac{S_B+S_k-S_f/5}{\eta_e\eta_a}$. $P_{out}^{(E)} = \eta\left[(1+k_T)S_f + S_B + S_k + \left(\frac{1-\eta_a}{\eta_a}\right)\left(S_B+S_k-\frac{S_f}{5}\right)\right]V$

$S_B\rightarrow 0$, $F = nT\tau_E$. $F_I = n_I T_I \tau_{EI}$.

$$\rightarrow Q_E = \frac{(6.4\eta\eta_e\eta_a + 1 - \eta\eta_e)F - (1-\eta\eta_e)F_I}{F_I - F}$$

$\eta=0.4$, $\eta_e=0.7$. $\eta_a=0.7$.

$$\rightarrow Q_E \approx \frac{2F - 0.72F_I}{F_I - F} = \frac{2nT\tau_E - 0.72\cdot\dfrac{3T_I^2}{\frac{k}{4}\langle\sigma v\rangle E_f}}{\dfrac{3T_I^2}{\frac{k}{4}\langle\sigma v\rangle E_f} - nT\tau_E} = \frac{2\cdot A\cdot F\cdot k - 0.72\cdot 3T_I^2}{3T_I^2 - A\cdot F\cdot k}, \quad A = \frac{1}{4}\langle\sigma v\rangle E_f.$$