International Tables for Crystallography (2013). Vol. D, Figure 1.7.3.14, p. 207.

$I^{\omega}_{\text{tot}}(X, Y, 0) = 2I^{\omega}(X, Y, 0)$ is the total initial fundamental intensity, $T^{2\omega}$ and T^{ω} are the transmission coefficients,

$$\frac{1}{v_b} = \frac{\Delta s}{4} + \left[1 + \left(\frac{\Delta s}{4}\right)^2\right]^{1/2}$$

with

$$\Delta s = (k^{2\omega} - k^{\omega})/\Gamma$$

and

$$\Gamma(X, Y) = \frac{\omega d_{\text{eff}}}{cn^{2\omega}}(T^{\omega})^{1/2}|E^{\omega}_{\text{tot}}(X, Y, 0)|. \qquad (1.7.3.59)$$

For the case of phase matching ($k^{\omega} = k^{2\omega}$, $T^{\omega} = T^{2\omega}$), we have $\Delta s = 0$ and $v_b = 1$, and the Jacobian elliptic function $\text{sn}(m, 1)$ is equal to $\tanh(m)$. Then formula (1.7.3.58) becomes

$$I^{2\omega}(X, Y, L) = I^{\omega}_{\text{tot}}(X, Y, 0)(T^{\omega})^2 \tanh^2[\Gamma(X, Y)L], \qquad (1.7.3.60)$$

where $\Gamma(X, Y)$ is given by (1.7.3.59).

The exit fundamental intensity $I^{\omega}(X, Y, L)$ can be established easily from the harmonic intensity (1.7.3.60) according to the Manley–Rowe relations (1.7.2.40), *i.e.*

$$I^{\omega}(X, Y, L) = I^{\omega}_{\text{tot}}(X, Y, 0)(T^{\omega})^2 \text{sech}^2[\Gamma(X, Y)L]. \qquad (1.7.3.61)$$

For small ΓL, the functions $\tanh^2(\Gamma L) \simeq \Gamma^2 L^2$ and $\text{sn}^2[(\Gamma L/v_b), v_b^4] \simeq \sin^2(\Gamma L/v_b)$ with $v_b \simeq 2/\Delta s$.

The first consequence of formulae (1.7.3.58)–(1.7.3.59) is that the various acceptance bandwidths decrease with increasing ΓL. This fact is important in relation to all the acceptances but in particular for the thermal and angular ones. Indeed, high efficiencies are often reached with high power, which can lead to an important heating due to absorption. Furthermore, the divergence of the beams, even small, creates a significant dephasing: in this case, and even for a propagation along a phase-matching direction, formula (1.7.3.60) is not valid and may be replaced by (1.7.3.58) where $k(2\omega) - k(\omega)$ is considered as the 'average' mismatch of a parallel beam.

In fact, there always exists a residual mismatch due to the divergence of real beams, even if not focused, which forbids asymptotically reaching a 100% conversion efficiency: $I^{2\omega}(L)$ increases as a function of ΓL until a maximum value has been reached and then decreases; $I^{2\omega}(L)$ will continue to rise and fall as ΓL is increased because of the periodic nature of the Jacobian elliptic sine function. Thus the maximum of the conversion efficiency is reached for a particular value $(\Gamma L)_{\text{opt}}$. The determination of $(\Gamma L)_{\text{opt}}$ by numerical computation allows us to define the optimum incident fundamental intensity I^{ω}_{opt} for a given phase-matching direction, characterized by K, and a given crystal length L.

The crystal length must be optimized in order to work with an incident intensity I^{ω}_{opt} smaller than the damage threshold intensity I^{ω}_{dam} of the nonlinear crystal, given in Section 1.7.5 for the main materials.

Formula (1.7.3.57) is established for type I. For type II, the second harmonic intensity is also an sn^2 function where the

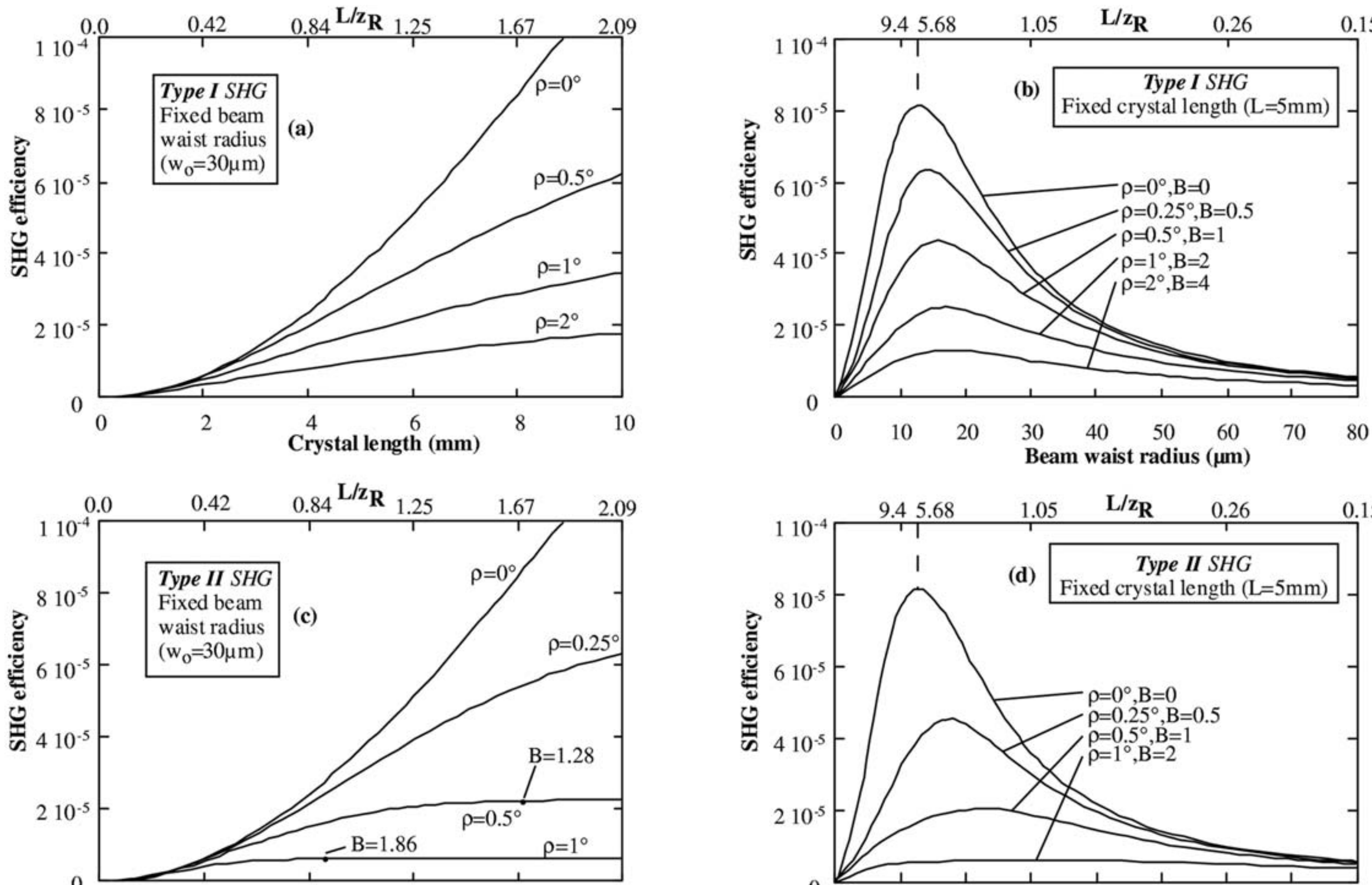

Fig. 1.7.3.14. Type-I and -II conversion efficiencies calculated as a function of L/z_R for different typical walk-off angles ρ: (*a*) and (*c*) correspond to a fixed focusing condition (w_o = 30 µm); the curves (*b*) and (*d*) are plotted for a constant crystal length (L = 5 mm); all the calculations are performed with the same effective coefficient (d_{eff} = 1 pm V^{-1}), refractive indices ($n_3^{2\omega}n_1^{\omega}n_2^{\omega} = 5.83$) and fundamental power [$P_{\omega}(0$ = 1 W]. B is the walk-off parameter defined in the text (Fève & Zondy, 1996).

references