# Jacobien

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2019, May 2

Transformation from invariant frame to lab frame and CM angle for the reaction $ep \rightarrow e'p'\gamma$. Calculation of the Jacobian matrix determinant as a function of invariants and beam energy:

$$\frac{d\sigma}{dx_b dQ^2 dt d\Phi} = \frac{2\pi}{4EE'} \frac{2Mx_b^2}{Q^2} \frac{M^2 + \frac{Q^2}{x_b} - Q^2}{2M\sqrt{Q^2 - (\frac{Q^2}{2Mx_b})^2} Q^2 (\frac{1}{x_b} - 1)} \frac{d\sigma}{dE' d\Omega' dcos(\Theta^{CM}_{\gamma^*\gamma}) d\Phi} \tag{1}$$

with $d\Omega' = sin\theta(e')d\theta(e')d\phi(e')$ corresponding to the scattered electron solid angle. Using $x_b = \frac{Q^2}{2M(E-E')}$ with E and E' beam and scattered electron energies, $Q^2$: photon virtuality, $\Phi$ leptons vs photons plane azimuthal angle, M: proton mass, $\Theta_{\gamma^*\gamma}$ polar angle of virtual to real photon in $\gamma^* p$ CM frame.