Computational Methods in Particle Physics

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Spring 2009

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Exercise 1: Higher Dimensional Integrals

To see how the higher dimensional integrals I_N^{D+2m}, associated with metric tensors $(g^{\cdot\cdot})^{\otimes m}$, arise in eq. (15), calculate the simplest non-trivial subpart of eq. (14), a rank two tensor, involving two loop momenta in the numerator:

$$L_N^{\mu_1\mu_2} \;=\; \Gamma(N)\int_0^\infty \prod_{i=1}^N dz_i\,\delta(1-\sum_{l=1}^N z_l)\int_{-\infty}^\infty \frac{d^Dl}{i\pi^{\frac{D}{2}}}\,l^{\mu_1}l^{\mu_2}\left[l^2-R^2+i\delta\right]^{-N}.$$

Note: The equation numbers refer to equations in the lecture notes.

Exercise 2: $\tilde{k}$-Integrals

Show that the effect of $(\tilde{k}^2)^\alpha$ in the numerator is to formally shift the integration from D to $D+2\alpha$ dimensions, i.e. derive the relation

$$\int \frac{d^Dk}{i\pi^{\frac{D}{2}}}\,(\tilde{k}^2)^\alpha\,f(k^\mu,k^2) \;=\; (-1)^\alpha\frac{\Gamma(\alpha+\frac{D}{2}-2)}{\Gamma(\frac{D}{2}-2)}\int \frac{d^{D+2\alpha}k}{i\pi^{\frac{D}{2}+\alpha}}f(k^\mu,k^2)\,.$$