F $\sigma = C_n \dfrac{*rdr}{r^n} \Rightarrow d\sigma = C_n\, d\left(\dfrac{*rdr}{r^n}\right) = C_n \Rightarrow d\left(\dfrac{1}{r^n}\right) \wedge (*rdr) = C_n(-n)\, r^{-n-1} dr \wedge *(rdr) = -\dfrac{nC_n}{r^{n+1}}\, dr \wedge *(rdr).$

We had better use $\sigma = C_n \dfrac{\sum \Phi_i(x)}{r^n}$.

$$d\sigma = C_n\, d\left(\frac{\sum \Phi_i}{r^n}\right) = C_n\, dr^{-n} \wedge \sum \Phi_i + \frac{1}{r^n}\, d\sum \Phi_i \cdot C_n$$

$$= C_n(-n)\, r^{-n-1} \sum \frac{x_i}{r} dx_i \wedge \sum \Phi_i + \frac{1}{r^n} \sum d\Phi_i \cdot C_n$$

$$= C_n(-n)\left(\sum \frac{x_i dx_i}{r^{n+2}}\right) \wedge (*rdr) + \frac{1}{r^n} \sum \Phi(x) \cdot C_n$$

$$= -C_n \frac{n}{r^{n+2}}\, r\,dr \wedge (*rdr) + \frac{n\Phi(x)}{r^n} \cdot C_n$$

$$= \left(\frac{n\Phi(x)}{r^n} - \frac{n r\,dr \wedge (*rdr)}{r^{n+2}}\right) C_n = C_n\left(\frac{n\Phi(x)}{r^n} - \frac{n\sum x_i dx_i \wedge \sum (-1)^{i-1} x_i\, dx_1 \wedge \cdots \wedge \widehat{dx_i} \wedge \cdots \wedge dx_n}{r^{n+2}}\right) = C_n\left(\frac{n\Phi(x)}{r^n} - \frac{n\, r^2\Phi}{r^{n+2}}\right) = 0.$$

By Stokes' theorem, then, the integral

$$\int_{\|x\|=\epsilon} \sigma$$

of σ over a sphere is independent of the radius $\epsilon > 0$.

F $$0 = \int_{B(0,\epsilon_1) - B(0,\epsilon_2)} d\sigma = \int_{\partial B(0,\epsilon_1) - \partial B(0,\epsilon_2)} \sigma$$ by Stokes' theorem.

Consequently, choosing C_n properly, σ is the unique form on $\mathbb{R}^n - \{0\}$ that is invariant under proper rotations,