Helmholtz Coils for MRP

The length of the saturated absorption cell is $l_c = 8\,\text{cm}$ and has a radius of $r_c = 1.25\,\text{cm}$. In order to create a magnetic field around this, we will use Helmholtz coils. The magnetic field of Helmholtz coils is given by

$$B = \left(\frac{4}{5}\right)^{3/2} \frac{\mu_0 n I}{R}. \tag{1}$$

We want to have the following conditions satisfied:

- $I = 1\,\text{A}$
- $0\,\text{g} \leq B \leq 10\,\text{g}$
- $R = 27/2\,\text{cm} = 0.135\,\text{m}$

Solving for the number of turns in each Helmholtz coil n to create the maximum magnetic field of 10 gauss, we find

$$\begin{aligned} n &= \left(\frac{5}{4}\right)^{3/2} \frac{RB}{\mu_0 I} \\ &= \left(\frac{5}{4}\right)^{3/2} \frac{(0.135\,\text{m})(0.001\,\text{T})}{\left(4\pi \times 10^{-7}\,\text{Tm/A}\right)(1\,\text{A})} \\ &\approx 150\,\text{turns} \end{aligned} \tag{2}$$

With of wire gauge of about 20 AWG (is this about standard?), the wire will have a diameter of about $w_d = 1\,\text{mm}$ and will be able to hold up to $10\,\text{A}$. The width of the coil will then need to be

$$\begin{aligned} L_{coil} &= \left(\frac{n}{x}\right) w_d \\ &= \left(\frac{150}{3}\right) 1\,\text{mm} \\ &= 5\,\text{cm} \end{aligned} \tag{3}$$

where n is the number of turns and x is the number of times the wire is layered (3 layers in this situation).

We will thus need length of wire

$$\begin{aligned} l_{wire} &= n * \text{circumference} * 2\,\text{coils} \\ &= 150\,\text{turns} * 2\pi\,(27/2\,\text{cm}) * 2 \\ &= 250\,\text{m} \end{aligned} \tag{4}$$