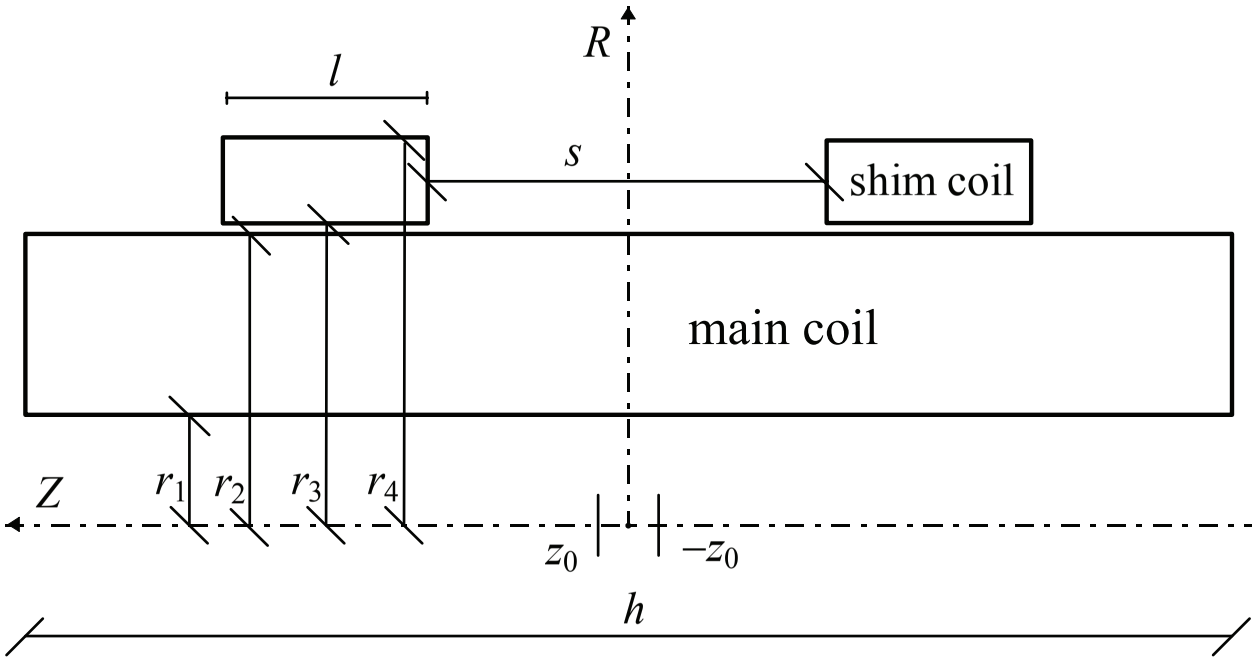
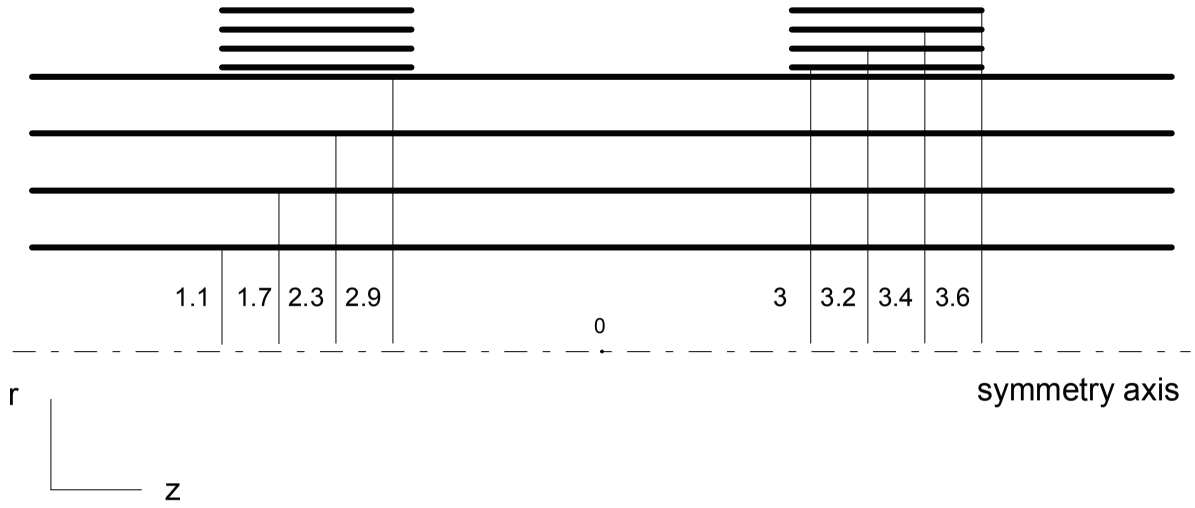
# GLOBAL OPTIMIZATION OF LONEY'S SOLENOID




$r_1 = 1.1$ cm $r_3 = 3.0$ cm $h = 12$ cm
$r_2 = 2.9$ cm $r_4 = 3.6$ cm $z_0 = 2.5$ mm

Longitudinal cross-section of Loney's solenoid.




Current-sheet model for magnetostatics analysis

$$B(z) = \frac{1}{2}\mu_0 nI \frac{Z + \frac{S}{2} + L}{\left[R^2 + Z^2 + \left(\frac{S}{2} + L\right)^2 + 2Z\left(\frac{S}{2} + L\right)\right]^{1/2}} - \frac{1}{2}\mu_0 nI \frac{Z + \frac{S}{2}}{\left[R^2 + Z^2 + \frac{S^2}{4} + ZS\right]^{1/2}}$$

*Given the values of all the other parameters, define the position s and the length $\ell$ of the two shim coils in such a way that the magnetic induction B be as uniform as possible in the controlled region ($-z_0$,$z_0$) on the axis.*

Constraints:

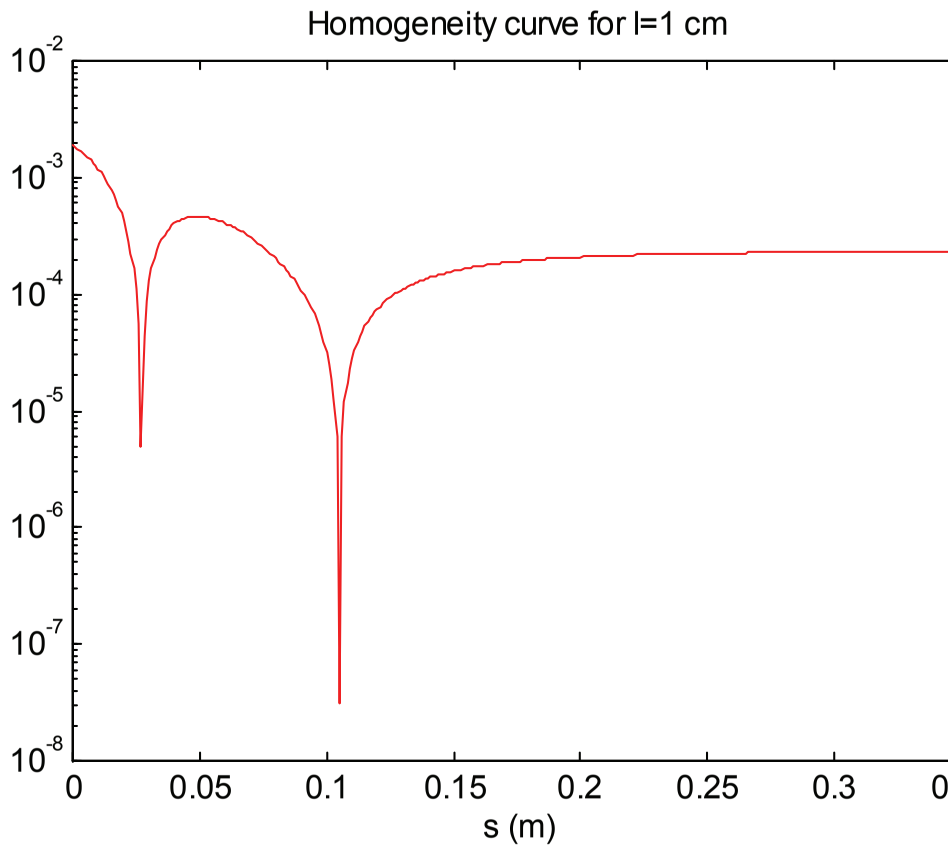
$s > 0$

$\ell > 0$

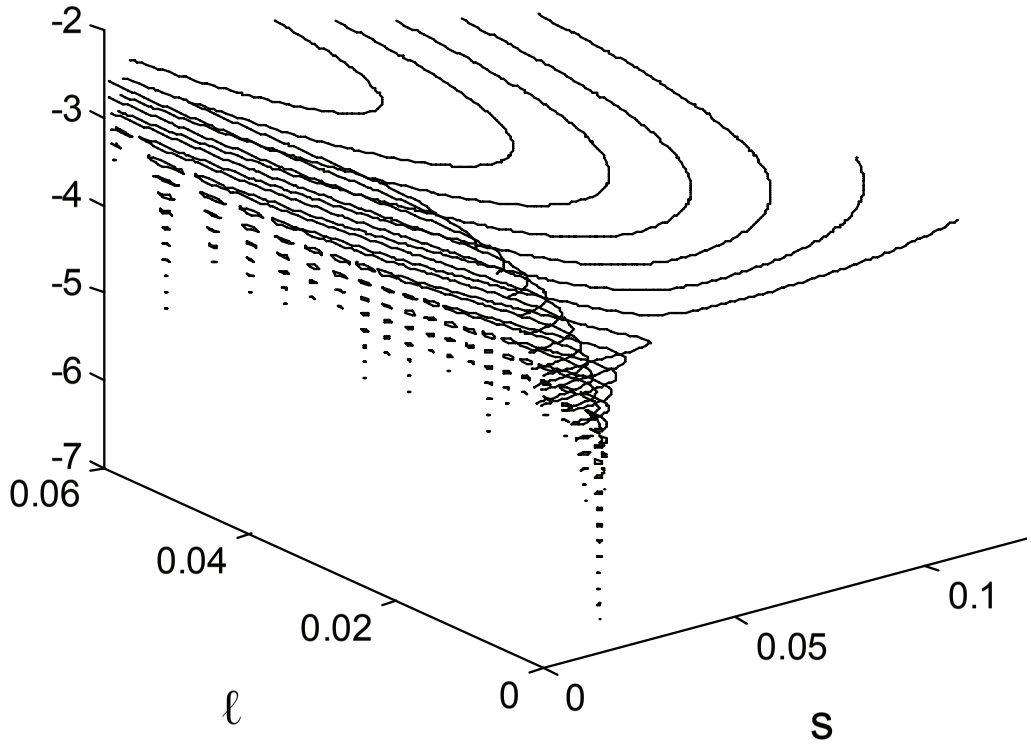
$s + 2\ell < h$

Objective function: $$D(s,\ell) = \frac{B_{max}(s,\ell) - B_{min}(s,\ell)}{B_0}$$

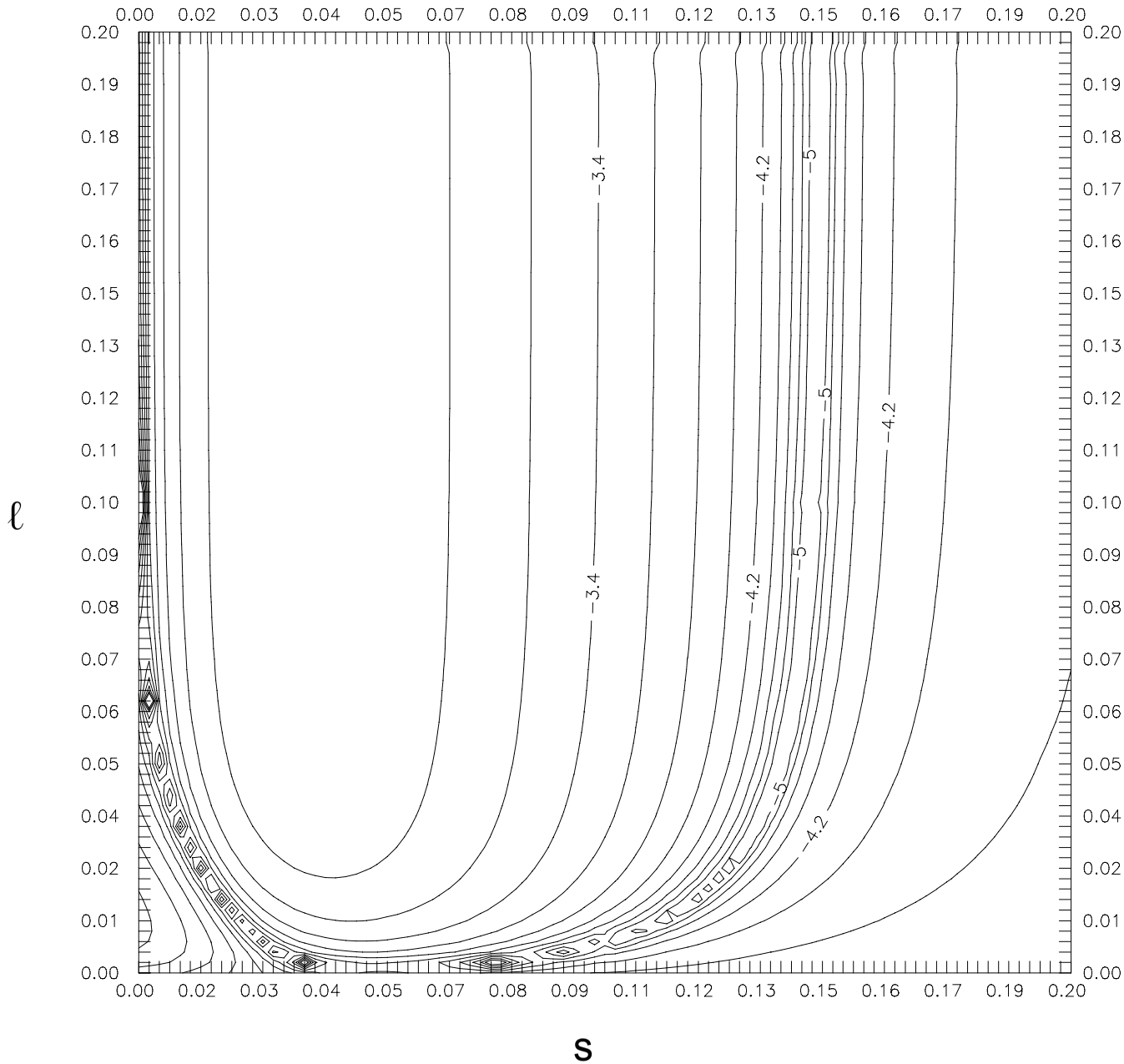
where $B_{max}$ and $B_{min}$ are the maximum and the minimum values of the magnetic induction in the interval $(-z_0, z_0)$ on the axis, $B_0$ is its value at the center of the solenoid.

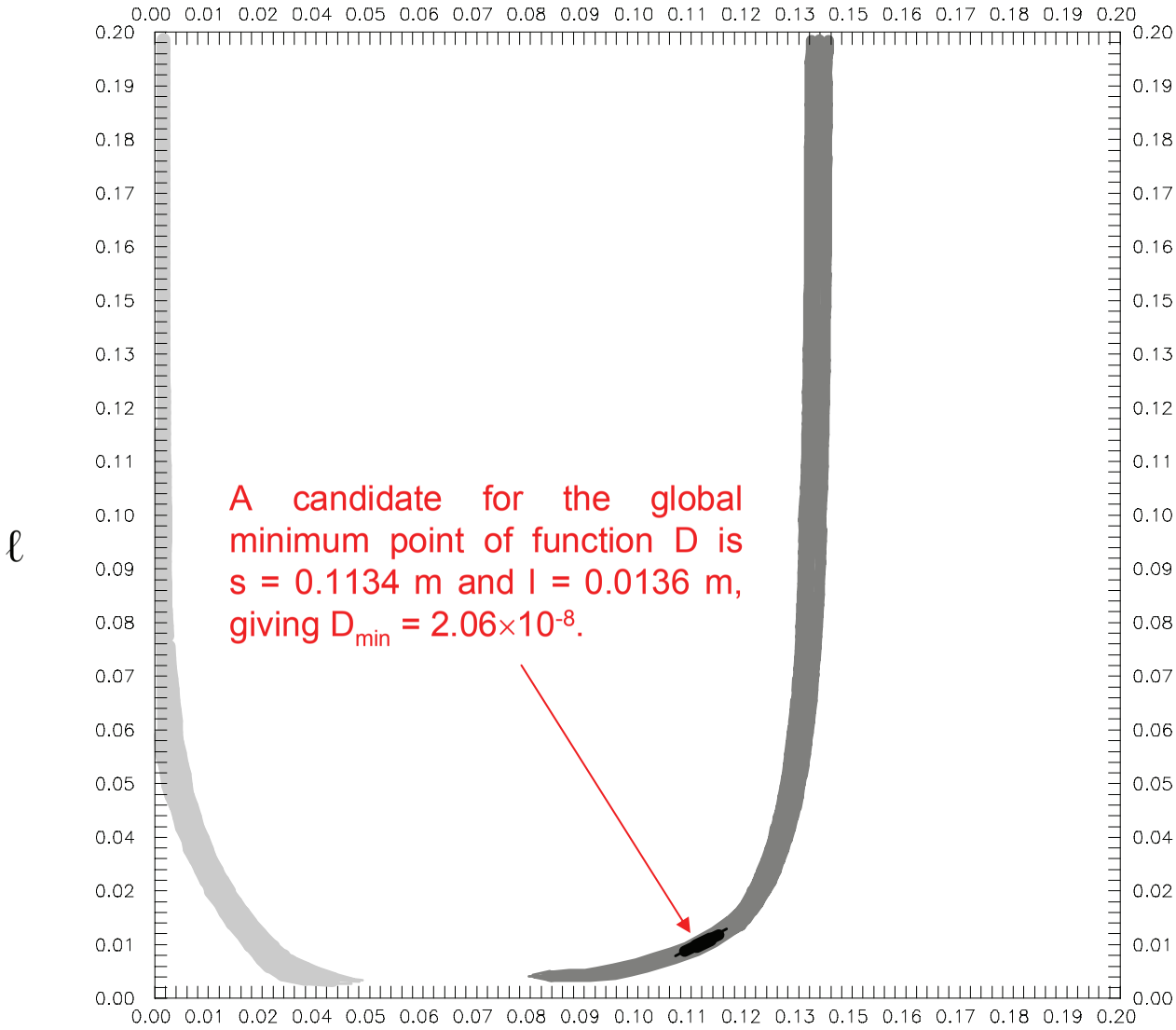



One-dimensional representation of D function.




Two-dimensional representation of D function.


0.00 0.02 0.03 0.04 0.05 0.07 0.08 0.09 0.11 0.12 0.13 0.15 0.16 0.17 0.19 0.20
0.20 0.19 0.18 0.17 0.16 0.15 0.13 0.12 0.11 0.10 0.09 0.08 0.07 0.06 0.05 0.04 0.02 0.01 0.00
-3.4
-4.2
-5
ℓ
s


0.00 0.01 0.02 0.04 0.05 0.06 0.07 0.08 0.09 0.10 0.11 0.12 0.13 0.15 0.16 0.17 0.18 0.19 0.20
0.20 0.19 0.18 0.17 0.16 0.15 0.13 0.12 0.11 0.10 0.09 0.08 0.07 0.06 0.05 0.04 0.02 0.01 0.00
A candidate for the global minimum point of function D is s = 0.1134 m and l = 0.0136 m, giving $D_{min} = 2.06 \times 10^{-8}$.
ℓ
s

# OPTIMIZATION RESULTS

| Method | $p_g$ | $p_l$ | $p_h$ | $n_f$ |
|---|---|---|---|---|
| Simplex* | 0.02 | 0.95 | 0.02 | 56 |
| Quasi-Newton | 0.02 | 0.98 | 0 | 266 |
| ES | 0.05 | 0.86 | 0.09 | 211 |
| ES-FF | 0.37 | 0.61 | 0.02 | 1981 |

* One failure has been detected over one hundred optimization runs.