QUANTITATIVE ESTIMATIONS OF THE ANOMALOUS PLASMA DIFFUSION IN AN ACTIVE REGION*

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In some recent papers the interdependence of the gas and magnetic-field motions in the solar atmosphere was considered. Some results indicate the occurrence of gas motion along the magnetic-field lines combined with motion of the field line, but sometimes we have to assume an obvious gas motion across the magnetic-field lines. As one of the possible mechanisms explaining this fact the anomalous plasma diffusion may be proposed.

In this paper we attempt to estimate the Böhm-diffusion effect. We are inconsistent in a certain sense using the Böhm-diffusion theory for a fully ionized plasma (Galeev *et al.*, 1963) in the case of a partly ionized plasma. In an unbounded medium the Bohm-diffusion coefficient has a maximal value

$$D^B_{\perp M} = \frac{ckT}{2\pi eH} = \frac{6.91 \times 10^6}{\vartheta H} \tag{1}$$

and in a system with longitudinal and transversal sizes L and ρL correspondingly it is

$$D^B_{\perp} = \frac{ckT}{2\pi eH}\,\frac{H_*}{H} \tag{1'}$$

where

$$H_* = \frac{c}{e}\left(\frac{\nu_{\mathrm{ei}} m_{\mathrm{i}} m_{\mathrm{e}} k T_{\mathrm{e}}}{\rho^4 L^2}\right)^{1/3} = 4.09 \times 10^5 \left(\frac{\mu_{\mathrm{i}} r_{\mathrm{ei}}^2 P_{\mathrm{e}}}{\rho^4 L^2 \sqrt{\vartheta}}\right)^{1/3}. \tag{2}$$

The Böhm diffusion is effective when it is not masked by the classical diffusion

$$D^B_{\perp M} > D^C_{\perp}. \tag{3}$$

Taking into account both the low ionization degree plasma and the almost fully ionized one we must write down in a rough approximation

$$D^C_{\perp} \approx D^A_{\perp} + D^L_{\perp}, \tag{4}$$

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where $D^A_\perp$ is the ambipolar diffusion coefficient in the fully ionized plasma, and $D^L_\perp$ is the classical diffusion coefficient in the low ionized plasma. Then a critical value of the magnetic field strength H_0, when the relation (3) is correct, is

$$H_0 \geqslant 1.90 \times 10^{14} P_e r_{ei}^2 \sqrt{\vartheta} \left\{ 1 + 21.3 \frac{P_n r_{in}^2}{P_e r_{ei}^2} \sqrt{\frac{\mu_i \mu_n}{\mu_i + \mu_n}} \right\}. \tag{5}$$

Using the data given in Appendix C of the paper by Zwaan (1965) we have computed $\log H_0$ in gausses (Table 1), $\log H_*(\rho^4 L^2)^{1/3}$ (Table 2), and $\log D^B_{\perp M}$ (Table 3) for some values of ϑ and P_g. We have taken $r_{in}^2 = 10^{-15}$ cm^2 and the values $D^B_\perp$ Max are computed for $H = H_0$ according to Equation (1). All designations are the same as in our previous papers (Kuklin, 1966; Kopecký and Kuklin, 1966, 1967).

Table 1

$\log H_0$

$\log P_g/\vartheta$	0.8	1.1	1.4	1.7
3.0	3.50	3.70	3.75	3.79
4.5	5.04	5.20	5.25	5.29
6.0	6.60	6.70	6.75	6.79

Table 2

$\log H_*(\rho^4 L^2)^{1/3}$

$\log P_g/\vartheta$	0.8	1.1	1.4	1.7
3.0	1.58	1.50	1.39	1.23
4.5	1.90	1.91	1.73	1.62
6.0	2.30	2.25	2.10	1.94

Table 3

$\log D^B_\perp$

$\log P_g/\vartheta$	0.8	1.1	1.4	1.7
3.0	3.44	3.10	2.94	2.82
4.5	1.90	1.60	1.44	1.32
6.0	0.34	0.10	−0.06	−0.18

Looking through the tables we can be convinced that within the physical parameter range of the sunspotss the photosphere, the low chromosphere, and the faculae, the Böhm-diffusion effect is negligible for the macroscopic regions. It is caused firstly by too high critical values of H_0, which seldom occur in reality; secondly by too low values of $D^B_\perp$, which can not explain usually observed discrepancies; and thirdly by too low values of $H_{*}(\rho^4 L^2)^{1/3}$. One can see that the filament in the sunspot penumbra with $\rho \approx 10^{-3}$ and $H_{*} \sim 1$ gauss cannot be longer than tens of kilometers. So the Böhm diffusion would have some meaning for systems of such sizes only, but it does not exclude the possibility for other anomalous diffusion types to be essential.

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