Erratum "PDRF: A general dispersion relation solver for magnetized multi-fluid plasma"

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Erratum to "H. S. Xie, PDRF: A general dispersion relation solver for magnetized multi-fluid plasma, Computer Physics Communications, 185, 670 - 675 (2014)". http://dx.doi.org/10.1016/j.cpc.2013.10.012

1. Eq.(3b), $P_{\parallel,\perp j1} = c^2_{\parallel,\perp j} n_{j1}$ should be $P_{\parallel,\perp j1} = c^2_{\parallel,\perp j} m_j n_{j1}$. Eq.(7), matrix elements $M_{21} = \frac{-ik_x c^2_{\perp j}}{\rho_{j0}}$ and $M_{41} = \frac{-ik_z c^2_{\parallel j}}{\rho_{j0}}$ should be $M_{21} = \frac{-ik_x c^2_{\perp j}}{n_{j0}}$ and $M_{41} = \frac{-ik_z c^2_{\parallel j}}{n_{j0}}$, which will affect the pressure $P \neq 0$ modes. Accordingly, these terms in the 'pdrf.m' code should also be corrected. Fig.2 (see the below Fig.1) in the paper should also be updated by the below Fig.2.

2. The MATLAB code 'pdrf.m' will meet roundoff error when the non-zero elements of matrix $\boldsymbol{M}$ has $max(|M_{ij}|)/min(|M_{ij}|) > 10^{16}$ and thus can not calculate the low frequency mode correctly. This can be resolved by changing the line in function 'pdrfsolver()'

   'd=eig(M,A);'

   to

   'MA=A\M;d0=vpa(eig(MA),16);d=double(d0);'.

We do a further benchmark with SI unit B_0=8.0E-9, c=2.9979E8, ϵ_0=8.854E-12, $\gamma_{\parallel j} = \gamma_{\perp j} = 5/3$ and input file 'pdrf_SI.in':

qs	ms	ns	vsx	vsy	vsz	csz	csp	epsnjx	epsnjy
-1.602E-19	9.109E-31	8.7E6	0.0	0.0	0.0	4.631E6	4.631E6	0.0	0.0
1.602E-19	1.673E-27	8.7E6	0.0	0.0	0.0	9.360E4	9.360E4	0.0	0.0

which gives $\beta_e = 4.0$, $\beta_i = 3.0$, $\omega_{ce} = -1.407 \times 10^3$, $\omega_{ci} = 0.766$, $c_{se} = 4.631 \times 10^6$, $c_s = 1.430 \times 10^5$, $\omega_{pe} = 1.664 \times 10^5$ and $v_A = 5.9 \times 10^4$. For $k = k_\parallel$, the analytical solutions include: (a) $\omega^2 \simeq \omega^2_{pe} + k^2 c^2_{se}$; (b) $k \gg 1$, $\omega^2 \simeq k^2 c^2$, $\omega \simeq \omega_{ce}$, $\omega \simeq \omega_{ci}$; (c) $k \ll 1$, $\omega^2 \simeq k^2(c^2_{si} + \frac{m_e}{m_i} c^2_{se}) = k^2 c^2_s$, $\omega^2 \simeq k^2 v^2_A$. The benchmark results are shown in Fig.3.

Other minor corrections:

1. In Fig.1, Fig.4 and Fig.5, the x-label kc should be kc/ω_{ce}, although $\omega_{ce} = 1$ in those test cases.

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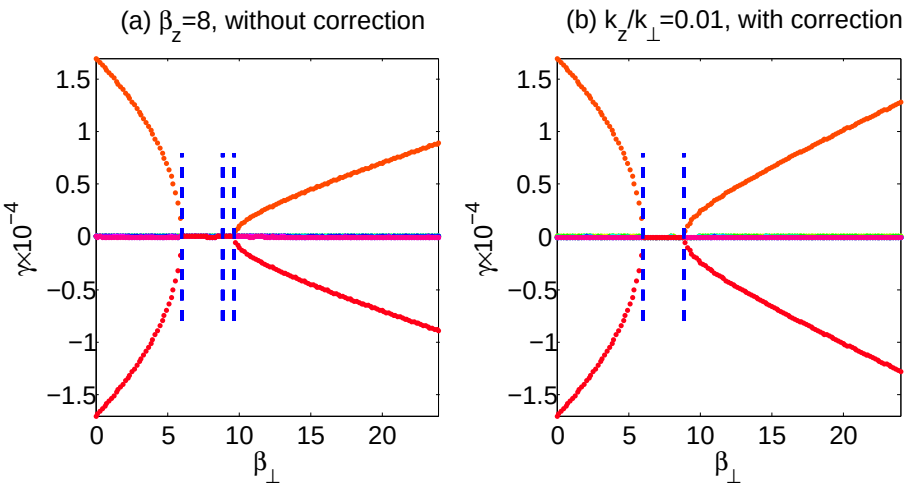

Figure 1: Previous Fig.2, the thresholds $\beta_\perp$ for firehose and mirror modes are correct, but the quantitative value of γ is incorrect.

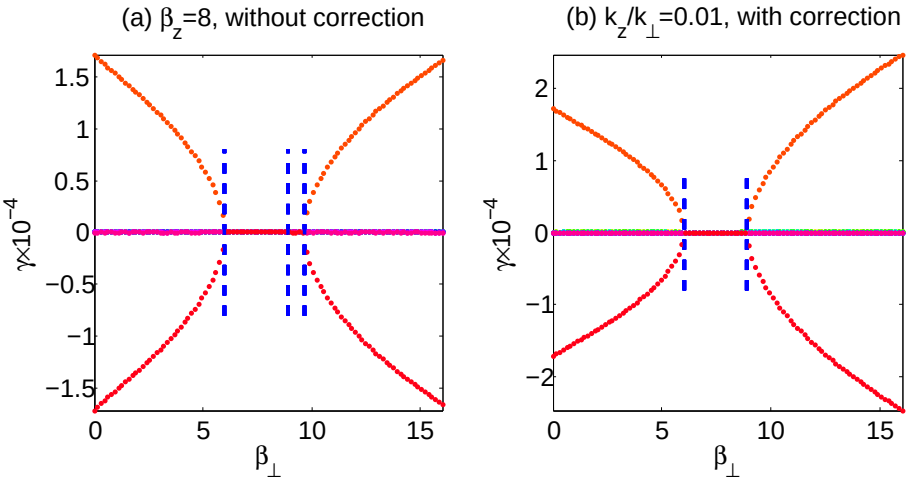

Figure 2: Correction of previous Fig.2. The quantitative value of γ is corrected.

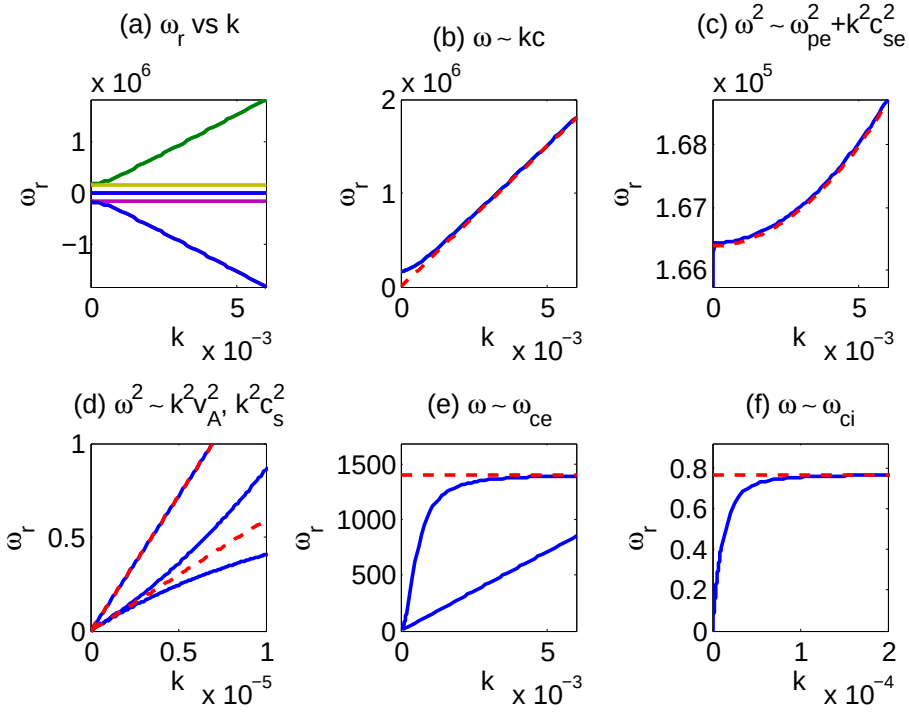

Figure 3: Benchmark of $k = k_{\|}$ modes with $\beta \neq 0$.

2. Eq.(9), a typo, $\delta p_{\perp} = 2p_{\perp}(1 - \frac{p_{\perp}}{p_{\|}})\delta B_{\perp}$ should be $\delta p_{\perp} = 2p_{\perp}(1 - \frac{p_{\perp}}{p_{\|}})\delta B_{\perp}/B_0$. This does not affect the main text and the code.

3. Table 3, all ω should be $-\omega$.

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