Effects of shear and rotation on the mean electromotive force

1

1.1

Assume homogeneous isotropic background turbulence. Influences of mean shear and rotation on mean electromotive force $\boldsymbol{\mathcal{E}}$ weak, i.e., $\boldsymbol{\mathcal{E}}$ linear in shear and angular velocity.
By symmetry arguments

$$\begin{aligned}\boldsymbol{\mathcal{E}} &= -\beta^{(0)}\boldsymbol{\nabla}\times\overline{\boldsymbol{B}} - \beta^{(D)}\boldsymbol{D}\cdot(\boldsymbol{\nabla}\times\overline{\boldsymbol{B}}) - (\delta^{(W)}\boldsymbol{W} + \delta^{(\Omega)}\boldsymbol{\Omega})\times(\boldsymbol{\nabla}\times\overline{\boldsymbol{B}}) \\ &\quad -(\kappa^{(W)}\boldsymbol{W} + \kappa^{(\Omega)}\boldsymbol{\Omega})\cdot(\boldsymbol{\nabla}\overline{\boldsymbol{B}})^{(s)} - \kappa^{(D)}\hat{\boldsymbol{\kappa}}(\boldsymbol{D})\cdot(\boldsymbol{\nabla}\overline{\boldsymbol{B}})^{(s)}\,,\end{aligned} \tag{1}$$

with coefficients $\beta^{(0)}$, $\beta^{(D)}$, $\delta^{(\Omega)}$, $\delta^{(W)}$, $\kappa^{(\Omega)}$, $\kappa^{(W)}$ and $\kappa^{(D)}$ independent of $\boldsymbol{D}$, $\boldsymbol{W}$ and $\boldsymbol{\Omega}$,
$(\boldsymbol{\nabla}\overline{\boldsymbol{B}})^{(s)}$ symmetric part of the gradient tensor of $\overline{\boldsymbol{B}}$ (i.e., $(\boldsymbol{\nabla}\overline{\boldsymbol{B}})^{(s)}_{ij} = (1/2)(\partial\overline{B}_i/\partial x_j + \partial\overline{B}_j/\partial x_j)$),
$\hat{\kappa}_{ijk} = \epsilon_{ijl}D_{lk} + \epsilon_{ikl}D_{lj}$,
$\boldsymbol{D}$ deformation tensor (i.e., $D_{ij} = (1/2)(\partial\overline{U}_i/\partial x_j + \partial\overline{U}_j/\partial x_j)$), $\boldsymbol{W} = \boldsymbol{\nabla}\times\overline{\boldsymbol{U}}$,
$\boldsymbol{\Omega}$ angular velocity which determines Coriolis force.
See RS06.

1.2

Assume

$$\overline{\boldsymbol{U}} = (0, Sx, 0)\,, \quad \boldsymbol{\Omega} = (0, 0, \Omega) \tag{2}$$

with constants S and Ω.
Then

$$\boldsymbol{W} = (0, 0, S)\,, \quad D_{ij} = \frac{1}{2}S\,(\delta_{i1}\delta_{j2} + \delta_{i2}\delta_{j1})\,. \tag{3}$$

1.3

Assume further that $\overline{\boldsymbol{B}}$ is independent of x and y,

$$\overline{\boldsymbol{B}} = (\overline{B}_x(z), \overline{B}_y(z), \overline{B}_z)\,. \tag{4}$$

$\overline{B}_z$ must be independent of z, too. Then

$$\boldsymbol{\nabla}\times\overline{\boldsymbol{B}} = \mu\boldsymbol{J}\,, \quad \boldsymbol{J} = (J_x, J_y, 0)\,, \quad (\boldsymbol{\nabla}\overline{\boldsymbol{B}})^{(s)}_{ij} = -(\mu/2)(J_x(\delta_{i2}\delta_{j3} + \delta_{i3}\delta_{j2}) - J_y(\delta_{i1}\delta_{j3} + \delta_{i3}\delta_{j1})) \tag{5}$$

where

$$\mu J_x = -\frac{\partial\overline{B}_y}{\partial z}\,, \quad \mu J_y = \frac{\partial\overline{B}_x}{\partial z}\,. \tag{6}$$

1.4

Under the assumptions introduced so far equation (1) can be written in the form

$$\mathcal{E}_i = -\mu\,\eta_{ij}J_j\,. \tag{7}$$

We have then

$$\begin{aligned}\eta_{xx} &= \eta_{yy} = \eta zz = \beta^{(0)} \\ \eta_{xy} &= (\zeta^{(D)} - \zeta^{(W)})S - \zeta^{(\Omega)}\Omega \\ \eta_{yx} &= (\zeta^{(D)} + \zeta^{(W)})S + \zeta^{(\Omega)}\Omega \\ \eta_{xz} &= \eta_{yz} = \eta_{zx} = \eta_{zy} = 0\,,\end{aligned} \tag{8}$$

where

$$\zeta^{(D)} = \frac{1}{2}(\beta^{(D)} - \kappa^{(D)})\,, \quad \zeta^{(W)} = \delta^{(W)} - \frac{1}{2}\kappa^{(W)}\,, \quad \zeta^{(\Omega)} = \delta^{(\Omega)} - \frac{1}{2}\kappa^{(\Omega)}\,. \tag{9}$$

(In the case of rotation ($S=0$) we may also write $\mathcal{E}_i = -\mu\beta^{(0)}\, J_i + \zeta^{(\Omega)}\Omega\, \mathrm{d}\overline{B}_i/\mathrm{d}z$.)
Simulations under the assumptions of sections 1.2 and 1.3 do not deliver us the seven coefficients $\beta^{(0)}$, $\beta^{(D)}$, $\delta^{(\Omega)}$, $\delta^{(W)}$, $\kappa^{(\Omega)}$, $\kappa^{(W)}$ and $\kappa^{(D)}$ but only $\beta^{(0)}$ and the three combinations $\zeta^{(D)}$, $\zeta^{(W)}$ and $\zeta^{(\Omega)}$. We have, e.g.,

$$\beta^{(0)} = \frac{1}{2}\left(\eta_{xx} + \eta_{yy}\right), \tag{10}$$

in the case of shear ($\Omega = 0$)

$$\zeta^{(D)} = \frac{1}{2S}\left(\eta_{xy} + \eta_{yx}\right), \quad \zeta^{(W)} = -\frac{1}{2S}\left(\eta_{xy} - \eta_{yx}\right), \tag{11}$$

and in the case of rotation ($S = 0$)

$$\zeta^{(\Omega)} = -\frac{1}{2\Omega}\left(\eta_{xy} - \eta_{yx}\right). \tag{12}$$

1.5

Numerical results can contribute to answers to the following questions.

(a) Applies $\beta^{(0)} = \frac{1}{3} u_{\mathrm{rms}}^2 \tau_{cor}$ (for $R_m \gg 1$) also with $St = u_{\mathrm{rms}}\tau_c/\lambda_c = O(1)$?
Has $\beta^{(0)}$ really no "magnetic part" (cf., e.g., RR07)?

(b) Is a "$\boldsymbol{W} \times \boldsymbol{J}$ dynamo" possible?
Dynamos of that kind are impossible with an incompressible fluid and purely hydrodynamic background turbulence as long as SOCA applies (RS06, RK06).
Assume mean magnetic field $\sim \exp(\mathrm{i}kz)$ and $\Omega = 0$.
A necessary condition for a growing magnetic field is $\eta_{yx}(S + \eta_{xy}k^2) > 0$ (Brandenburg et al. ...)
or, equivalently, $\delta(1 - \delta' k^2) > 0$ with $\delta = \zeta^{(D)} + \zeta^{(W)}$ and $\delta' = -\zeta^{(D)} + \zeta^{(W)}$ (RS06).
Excluding cases in which the neglect of contributions to $\boldsymbol{\mathcal{E}}$ with higher–order derivatives of $\overline{\boldsymbol{B}}$ is questionable we may reduce this conditions to $\eta_{yx}S > 0$ or $\delta > 0$.

(c) Under which conditions has the $\boldsymbol{\Omega} \times \boldsymbol{J}$–effect a reasonable magnitude?
It vanishes in SOCA for an incompressible fluid with purely hydrodynamic background turbulence both in the high–conductivity and in the low–conductivity limit.

2

2.1

Consider for a moment SOCA results. For purely hydrodynamic background turbulence (kinetic forcing) RS06 delivers

$$\beta^{(0)} = \frac{1}{9}\frac{u_{\mathrm{rms}}^2\lambda_c^2}{\eta}\,\hat{\beta}^{(0)}(q) \tag{13}$$

and

$$\begin{aligned}
\beta^{(D)} &= \frac{7}{90}\frac{u_{\mathrm{rms}}^2\lambda_c^4}{\eta^2}\,\hat{\beta}^{(D)}(P_m, q)\,, \quad \kappa^{(D)} = \frac{13}{90}\frac{u_{\mathrm{rms}}^2\lambda_c^4}{\eta^2}\,\hat{\kappa}^{(D)}(P_m, q) \\
\delta^{(W)} &= \frac{1}{36}\frac{u_{\mathrm{rms}}^2\lambda_c^4}{\eta^2}\,\hat{\delta}^{(W)}(q)\,, \quad \kappa^{(W)} = -\frac{1}{90}\frac{u_{\mathrm{rms}}^2\lambda_c^4}{\eta^2}\,\hat{\kappa}^{(W)}(P_m, q) \\
\delta^{(\Omega)} &= -\frac{\sqrt{\pi}}{36\sqrt{2}}\frac{u_{\mathrm{rms}}^2\lambda_c^4}{\eta^2}\sqrt{q}\,\hat{\delta}^{(\Omega)}(P_m, q)\,, \quad \kappa^{(\Omega)} = \frac{\sqrt{\pi}}{18\sqrt{2}}\frac{u_{\mathrm{rms}}^2\lambda_c^4}{\eta^2}\sqrt{q}\,\hat{\kappa}^{(\Omega)}(P_m, q)\,,
\end{aligned} \tag{14}$$

Here λ_c means a correlation length, $\hat{\beta}^{(0)}$, $\hat{\beta}^{(D)}$, ... $\hat{\kappa}^{(\Omega)}$ are dimensionless functions of the magnetic Prandtl number P_m and the parameter q, or q only,

$$P_m = \frac{\nu}{\eta}\,, \quad q = \frac{\lambda_c^2}{\eta\tau_c}\,. \tag{15}$$

These functions approach unity for $P_m = 1$ and $q \to 0$. If $St = u_{\mathrm{rms}}\tau_c/\lambda_c = 1$, with τ_c being a correlation time, we have $q = R_m$, where

$$R_m = \frac{u_{\mathrm{rms}}\lambda_c}{\eta}\,. \tag{16}$$

With (9) and (14) we obtain

$$\zeta^{(D)} = -\frac{1}{30} \frac{u_{\rm rms}^2 \lambda_c^4}{\eta^2} \hat{\zeta}^{(D)}, \quad \zeta^{(W)} = \frac{1}{30} \frac{u_{\rm rms}^2 \lambda_c^4}{\eta^2} \hat{\zeta}^{(W)}, \quad \zeta^{(\Omega)} = -\frac{\sqrt{\pi}}{18\sqrt{2}} \frac{u_{\rm rms}^2 \lambda_c^4}{\eta^2} \sqrt{q}\, \hat{\zeta}^{(\Omega)} \tag{17}$$

with

$$\hat{\zeta}^{(D)} = \frac{-7\hat{\beta}^{(D)} + 13\hat{\kappa}^{(D)}}{6}, \quad \hat{\zeta}^{(W)} = \frac{5\hat{\delta}^{(W)} + \hat{\kappa}^{(W)}}{6}, \quad \hat{\zeta}^{(\Omega)} = \frac{\hat{\delta}^{(\Omega)} + \hat{\kappa}^{(\Omega)}}{2}. \tag{18}$$

The $\hat{\zeta}^{(D)}$, $\hat{\zeta}^{(W)}$ and $\hat{\zeta}^{(\Omega)}$ are dimensionless and depend on P_m and q. For $P_m = 1$ and $q \to 0$ they approach unity. This implies that in this limit $\delta = \zeta^{(D)} + \zeta^{(W)} = 0$.

It is very important to extend the results to the case of mhd background turbulence (magnetic forcing)!!!

2.2

Abolishing the restriction to SOCA we represent the results for $\beta^{(0)}$, $\zeta^{(D)}$, $\zeta^{(W)}$ and $\zeta^{(\Omega)}$ again in the form of (13) and (17) but with reinterpreted $\hat{\beta}^{(0)}$, $\hat{\zeta}^{(D)}$, $\hat{\zeta}^{(W)}$ and $\hat{\zeta}^{(\Omega)}$. We consider them again as functions of P_m, further of R_m (possibly also St) and of the Mach number $M = u_{\rm rms}/c_s$, where c_s means the sound speed. In the case of mhd background turbulence (magnetic forcing) they depend in general on the Alfven number $A = b_{\rm rms}/\sqrt{\mu\varrho}\, u_{\rm rms}$, too.

As soon as SOCA results for mhd background turbulence are available this concept could be slightly modified.

2.3

In the numerical simulation instead of the original quantities $\boldsymbol{\mathcal{E}}$, $\overline{\boldsymbol{B}}$, η_{ij}, $\beta^{(0)}$, $\zeta^{(\cdot\cdot)}$, δ, ν, η, S, Ω, $u_{\rm rms}$, $b_{\rm rms}$, etc. dimensionless ones occur, which we denote by $\tilde{\boldsymbol{\mathcal{E}}}$, $\tilde{\overline{\boldsymbol{B}}}$, $\tilde{\eta}_{ij}$, $\tilde{\beta}^{(0)}$, $\tilde{\zeta}^{(\cdot\cdot)}$, $\tilde{\delta}$, $\tilde{\nu}$, $\tilde{\eta}$, $\tilde{S}$, $\tilde{\Omega}$, $\tilde{u}_{\rm rms}$, $\tilde{b}_{\rm rms}$, etc. They are defined by

$$\begin{aligned}
\tilde{\boldsymbol{\mathcal{E}}} &= \boldsymbol{\mathcal{E}}/\sqrt{\mu\varrho}c_s^2, \quad \tilde{\overline{\boldsymbol{B}}} = \overline{\boldsymbol{B}}/\sqrt{\mu\varrho}c_s \\
\tilde{\eta}_{ij} &= \eta_{ij}/c_s l, \quad \tilde{\beta}^{(0)} = \beta^{(0)}/c_s l, \quad \tilde{\zeta}^{(\cdot\cdot)} = \zeta^{(\cdot\cdot)}/c_s l, \quad \tilde{\delta} = \delta/c_s l \\
\tilde{\nu} &= \nu/c_s l, \quad \tilde{\eta} = \eta/c_s l, \quad \tilde{S} = Sl/c_s, \quad \tilde{\Omega} = \Omega l/c_s \\
\tilde{u}_{\rm rms} &= u_{\rm rms}/c_s, \quad \tilde{b}_{\rm rms} = b_{\rm rms}/c_s\sqrt{\mu\varrho},
\end{aligned} \tag{19}$$

where c_s is again the sound speed and l a typical length of the box ($k_1 l = 2\pi$). In the simulations the time is measured in units of l/c_s ("sound crossing time"). [How to understand ϱ?]
We put further

$$\lambda_c = l\frac{k_1}{k_f}. \tag{20}$$

With these definitions we have

$$\tilde{\beta}^{(0)} = \frac{9}{2} \frac{\tilde{\eta}(\tilde{\eta}_{xx} + \tilde{\eta}_{yy})}{\tilde{u}_{\rm rms}^2} \left(\frac{k_f}{k_1}\right)^2 = 9 \frac{\tilde{\eta}\tilde{\eta}_t}{\tilde{u}_{\rm rms}^2} \left(\frac{k_f}{k_1}\right)^2 \tag{21}$$

and

$$R_m = \frac{\tilde{u}_{\rm rms}}{\tilde{\eta}} \frac{k_1}{k_f}. \tag{22}$$

In the case of shear ($\Omega = 0$) we have further

$$\hat{\zeta}^{(D)} = -15 \frac{\tilde{\eta}^2(\tilde{\eta}_{xy} + \tilde{\eta}_{yx})}{\tilde{u}_{\rm rms}^2 \tilde{S}} \left(\frac{k_f}{k_1}\right)^4, \quad \hat{\zeta}^{(W)} = -15 \frac{\tilde{\eta}^2(\tilde{\eta}_{xy} - \tilde{\eta}_{yx})}{\tilde{u}_{\rm rms}^2 \tilde{S}} \left(\frac{k_f}{k_1}\right)^4. \tag{23}$$

Putting

$$\delta = \zeta^{(D)} + \zeta^{(W)} = \frac{1}{30} \frac{u_{\rm rms}^2 \lambda_c^4}{\eta^2} \hat{\delta} \tag{24}$$

we obtain

$$\hat{\delta} = -(\hat{\zeta}^{(D)} - \hat{\zeta}^{(W)}). \tag{25}$$

In the case of rotation ($S = 0$) we find under the assumption $St = u_{\rm rms}\tau_c/\lambda_c = 1$ (which implies $q = R_m$)

$$\hat{\zeta}^{(\Omega)} = \frac{9\sqrt{2}}{\sqrt{\pi}} \, \frac{\tilde{\eta}^{5/2}(\tilde{\eta}_{xy} - \tilde{\eta}_{yx})}{\tilde{u}_{\rm rms}^{5/2}\tilde{\Omega}} \left(\frac{k_f}{k_1}\right)^{9/2} = \frac{9\sqrt{2}}{\sqrt{\pi}} \, \frac{\tilde{\eta}^{5/2}\tilde{v}}{\tilde{u}_{\rm rms}^{5/2}} \left(\frac{k_f}{k_1}\right)^{9/2}, \tag{26}$$

where $\tilde{v}$ stands for the values given under "2del-kap".
Corresponds "2del-kap" really to our $\hat{\zeta}^{(\Omega)}$, or to $\hat{\zeta}^{(\Omega)}\tilde{\Omega}$??? In the last case a factor $\tilde{\Omega}$ had to be inserted into the denominator of the last expression of (26).
It would be desirable to check the assumption $St = 1$. This requires the determination of τ_c, e.g., from $\int_0^\infty \overline{\boldsymbol{u}(t) \cdot \boldsymbol{u}(t-\tau)} \, \mathrm{d}\tau = u_{\rm rms}^2 \tau_c$.

As long as
- the background turbulence is really homogeneous and isotropic (i.e., in particular no strong magnetic quenching, no strong shear, no strong Coriolis force (no Ω quenching))
- $P_m = 1$ and small R_m
- kinetic forcing only ($A = 0$)
- in case of rotation ($S = 0$) in addition St of the order of unity

the $\hat{\beta}^{(0)}$, $\hat{\zeta}^{(D)}$, $\hat{\zeta}^{(W)}$ and $\hat{\zeta}^{(\Omega)}$ should be of the order of unity.

3 Numerical results

Comments/questions concerning Tables 1 and 2
Coefficients $\hat{\beta}^{(0)}$, $\hat{\zeta}^{(D)}$ and $\hat{\zeta}^{(W)}$ should be independent of $\tilde{S}$ (as long as $\boldsymbol{\mathcal{E}}$ is linear in S).
The original data of kinshear16a(2) and kinshear16a(3) (in "notes") are in conflict with each other. Only one set of data can be correct.
NOSOCkinshear16h "dynamoverdächtig".
NOSOCmagShear32c, magnohel64F and magnohel64F "dynamoverdächtig".
The runs kinshear16d and NOSOCAkinshear16a should provide us with results close to those of SOCA in the low–conductivity limit. In that sense the numerical values obtained for $\hat{\zeta}^{(W)}$ are hardly understandable.
The run kinohel32D shows that this problem does not disappear with higher resolution.
A distinct dependence of $\beta^{(0)}$ on A?

Comments/questions concerning Tables 3 and 4
Coefficients $\hat{\beta}^{(0)}$ and $\hat{\zeta}^{(\Omega)}$ should be independent of $\tilde{\Omega}$ (as long as $\boldsymbol{\mathcal{E}}$ is linear in Ω).
A few results with smaller R_m would be very desirable.
SOCA results for R_m of order of unity or larger are questionable.
Have the values given under $\hat{\zeta}^{(\Omega)}$ to be divided by $\tilde{\Omega}$, see remark below (26)? They look then more reasonable!

Comments/questions concerning Tables 5 and 6
In the case $S = \Omega = 0$ the $\hat{\zeta}^{(D)}$, $\hat{\zeta}^{(W)}$ and $\hat{\zeta}^{(\Omega)}$ are meaningless. Here, e.g., $\tilde{\eta}_{xy}$ and $\tilde{\eta}_{yx}$ should be given. They should be sufficiently close to zero.
The values given for $\hat{\zeta}^{(\Omega)}$ are calculated with the last expression of (26) and therefore doubtful, see the remark below (26).

Table 1: Shear but no rotation ($\Omega = 0$), kinetic forcing ($A = 0$), $k_f/k_1 = 5$.

$\tilde{\eta}$	P_m	R_m	M	$\hat{\beta}^{(0)}$	$\hat{\zeta}^{(D)}$	$\hat{\zeta}^{(W)}$	$\hat{\delta}$	$\tilde{S}$	run
0.005	?	6.00	0.15	0.71000	0.79687	0.65104	-0.14583	-0.2	kinshear32b (SOCA!!)
0.001	?	40.00	0.20	0.00045	0.00680	0.01617	0.00937	-0.2	kinshear16a(1) (SOCA!!)
0.100	1	0.38	0.038	1.24	1.85	-0.22	-2.07	-0.2	kinshear16a(2) (SOCA)
0.050	1	0.21	0.05	1.42289	2.31861	0.10835	-2.21027	-0.2	kinshear16d (SOCA)
0.020	1	0.83	0.08	1.65917	2.81427	0.74575	-2.06852	-0.2	kinshear16b (SOCA)
0.200	0.5	0.038	0.038	2.48684	7.38833	-0.89595	-8.28428	-0.2	kinshear16a(3) (SOCA)
0.200	0.5	0.038	0.038	1.64855	3.20204	-0.95308	-4.15513	-0.2	NOSOCkinshear16f
0.100	1	0.076	0.038	1.24342	1.95745	-0.17854	-2.13599	-0.2	NOSOCkinshear16a
0.050	2	0.152	0.038	0.83362	0.74419	0.13715	-0.60704	-0.2	NOSOCkinshear16g
0.020	5	0.38	0.038	0.41447	0.17581	0.09427	-0.08154	-0.2	NOSOCkinshear16e
0.010	10	0.76	0.038	0.22749	0.05171	0.03723	-0.01448	-0.2	NOSOCkinshear16b
0.005	20	1.52	0.038	0.11842	0.01350	0.01118	-0.00232	-0.2	NOSOCkinshear16c
0.002	50	3.80	0.038	0.04893	0.00262	0.00234	-0.00029	-0.2	NOSOCkinshear16d
0.001	100	7.60	0.038	0.02633	0.00049	0.00069	0.00020	-0.2	NOSOCkinshear16h
0.100	1	0.072	0.036	1.48090	2.11588	-0.068721	-2.18461	-0.2	kinohel32D

Table 2: Shear but no rotation ($\Omega = 0$), magnetic forcing, $k_f/k_1 = 5$.

$\tilde{\eta}$	P_m	R_m	M	A	$\hat{\beta}^{(0)}$	$\hat{\zeta}^{(D)}$	$\hat{\zeta}^{(W)}$	$\hat{\delta}$	$\tilde{S}$	run
0.200	1	0.007	0.007	?	1.001	6.494	2.767	-3.727	-0.2	NOSOCmagshear16a(1
0.100	1	0.032	0.016	?	1.310	6.389	3.682	-2.706	-0.2	NOSOCmagshear16a(2
0.050	2	0.140	0.035	?	1.240	4.200	3.013	-1.186	-0.2	NOSOCmagshear16a(3
0.020	5	0.010	0.001	?	0.273	0.092	0.057	-0.036	-0.2	NOSOCmagShear32f
0.010	10	0.620	0.031	?	1.267	1.233	1.206	-0.027	-0.2	NOSOCmagShear32b
0.005	20	1.92	0.048	?	0.728	0.439	0.464	0.026	-0.2	NOSOCmagShear32c
0.10	1	0.03	0.015	12.00	2.59	9.58	4.92	-4.67	-0.2	magnohel32A
0.10	1	0.11	0.056	6.43	2.41	6.70	3.47	-3.23	-0.2	magnohel32B
0.10	1	0.39	0.20	3.52	1.76	2.23	1.79	-0.45	-0.2	magnohel32C
0.10	1	1.16	0.58	2.17	1.17	1.02	0.54	-0.48	-0.2	magnohel64D
0.10	1	2.50	1.25	1.61	0.57	1.12	0.12	-1.00	-0.2	magnohel64E
0.01	10	10.0	0.50	2.44	2.24 e-1	-4.26 e-3	1.97 e-2	2.40 e-2	-0.2	magnohel64H
0.0010	100	108.86	0.54	2.64	2.24 e-2	-5.93 e-5	1.65 e-5	7.59 e-5	-0.2	magnohel64F
0.0001	1000	1095.00	0.55	2.76	2.21 e-3	-2.6 e-7	-4.6 e-7	-1.9 e-7	-0.2	magnohel64G

Table 3: Rotation but no shear ($S = 0$), kinetic forcing ($A = 0$), $k_f/k_1 = 5$. SOCA if not indicated otherwise???

$\tilde{\eta}$	P_m	R_m	M	$\hat{\beta}^{(0)}$	$\hat{\zeta}^{(\Omega)}$	$\tilde{\Omega}$	run
0.005	?	5.96	0.15	1.16042	0.001615	0.01	rot32f
0.005	?	5.96	0.15	1.15535	0.002753	0.02	rot32g
0.005	?	5.96	0.15	1.11481	0.005072	0.1	rot32h
0.005	?	5.96	0.15	1.08441	0.007328	0.1	rot32c
0.005	?	6.00	0.15	1.07850	0.009569	0.2	rot32a
0.005	?	6.00	0.15	0.87500	0.008143	0.5	rot32b
0.005	?	6.08	0.15	0.68949	0.003486	1.0	rot32d
0.005	?	6.04	0.15	0.47564	0.000921	2.0	rot32e
0.005	?	5.96	0.15	0.81331	0.003602	0.1	rotNOSOCA32c
0.005	?	5.96	0.15	0.84523	0.007680	0.2	rotNOSOCA32a
0.005	?	6.00	0.15	0.73500	0.015676	0.5	rotNOSOCA32b
0.005	?	6.08	0.15	0.66709	0.007898	1.0	rotNOSOCA32d
0.005	?	6.00	0.15	0.48500	0.002056	2.0	rotNOSOCA32e
0.002	?	20.20	0.20	0.33526	0.000318	0.5	rot64a
0.002	?	19.50	0.20	0.31953	0.000048	0.2	rotNOSOCA64b
0.002	?	20.20	0.20	0.36063	0.001186	0.5	rotNOSOCA64c
0.002	?	25.50	0.26	0.15370	0.000087	1.0	rotNOSOCA64d
0.002	?	24.00	0.24	0.17531	0.000083	2.0	rotNOSOCA64e
0.001	?	45.79	0.23	0.16905	0.000010	0.5	rotNOSOCA128a2
0.001	?	45.79	0.23	0.15188	0.000022	0.5	rot128c

Table 4: Rotation but no shear ($S = 0$), magnetic forcing, $k_f/k_1 = 5$. SOCA if not indicated otherwise???

$\tilde{\eta}$	P_m	R_m	M	A	$\hat{\beta}^{(0)}$	$\hat{\zeta}^{(\Omega)}$	$\tilde{\Omega}$	run
0.005	?	2.65	0.07	1.98	1.52	0.004232	0.01	brot32h
0.005	?	2.65	0.07	1.98	1.57	0.007210	0.02	brot32g
0.005	?	2.65	0.07	1.98	1.48	0.009912	0.05	brot32f
0.005	?	2.64	0.07	1.98	1.39	0.010939	0.10	brot32a
0.005	?	2.60	0.07	2.00	1.30	0.009882	0.20	brot32b
0.005	?	2.40	0.06	2.23	1.27	0.007846	0.50	brot32c
0.005	?	2.10	0.05	2.65	1.57	0.005081	1.00	brot32d
0.005	?	1.73	0.04	3.36	2.19	0.002744	2.00	brot32e
0.005	?	?	?	?	?	?	0.01	brotNOSOCA32h
0.005	?	?	?	?	?	?	0.02	brotNOSOCA32g
0.005	?	?	?	?	?	?	0.05	brotNOSOCA32f
0.005	?	2.64	0.07	1.99	1.27	0.014322	0.10	brotNOSOCA32b
0.005	?	2.78	0.07	1.88	0.97	0.012817	0.20	brotNOSOCA32a
0.005	?	2.40	0.06	2.23	1.19	0.010663	0.50	brotNOSOCA32c
0.005	?	2.10	0.05	2.65	1.45	0.006774	1.00	brotNOSOCA32d
0.005	?	1.73	0.04	3.36	2.05	0.005488	2.00	brotNOSOCA32e
0.002	?	10.00	0.10	1.59	0.55	0.000273	0.10	brot64a
0.002	?	9.90	0.10	1.63	0.43	0.000407	0.20	brot64b
0.002	?	9.80	0.10	1.63	0.41	0.000890	0.20	brotNOSOCA64b
0.002	?	7.10	0.07	2.70	0.47	0.000855	2.00	brotNOSOCA64e
0.001	?	22.40	0.11	1.67	0.16	0.000023	0.50	brot128a
0.001	?	22.40	0.11	1.67	0.14	0.000121	0.50	brotNOSOCA128a3
0.001	?	22.00	0.11	1.64	0.23	0.000028	0.20	brot128b

Table 5: Neither shear nor rotation ($S = \Omega = 0$), kinetic forcing ($A = 0$), $k_f/k_1 = 5$. SOCA if not indicated otherwise???

$\tilde{\eta}$	P_m	R_m	M	$\hat{\beta}^{(0)}$	$\tilde{\eta}_{xy}$	$\tilde{\eta}_{xy}$	$[\hat{\zeta}^{(\Omega)}]$	run
0.005	?	5.96	0.15	0.93188	?	?	[-0.000104]	rotNOSOCA32o
0.002	?	19.29	0.19	0.31048	?	?	[0.000050]	rotNOSOCA64o
0.001	?	43.00	0.22	0.16180	?	?	[-0.000444]	rotNOSOCA128o
0.001	?	43.20	0.22	0.21841	?	?	[0.000002]	rot128o2

Table 6: Neither shear nor rotation ($S = \Omega = 0$), magnetic forcing, $k_f/k_1 = 5$. SOCA if not indicated otherwise???

$\tilde{\eta}$	P_m	R_m	M	A	$\hat{\beta}^{(0)}$	$\tilde{\eta}_{xy}$	$\tilde{\eta}_{xy}$	$[\hat{\zeta}^{(\Omega)}]$	run
0.005	?	2.65	0.07	1.98	1.59	?	?	[0.000470]	brot32o
0.002	?	10.00	0.10	1.59	0.45	?	?	[0.000159]	brotNOSOCA64o
0.001	?	23.80	0.12	1.50	0.25	?	?	[0.000003]	brot128o
0.001	?	23.20	0.12	1.53	0.18	?	?	[0.000087]	brotNOSOCA128o