Shear–current effect with small-scale dynamo?

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1 Background

Recent simulations suggest that shear–current effect might exist in the presence of a small-scale dynamo (Squire & Bhattacharjee, 2016). Earlier work using the TFM was entirely kinematic (Brandenburg et al., 2008). Here are now new quasi-kinematic calculations showing that η_{21} has still the wrong sign if there is a small-scale dynamo. Next, we may need to invoke the fully nonlinear method, which has not been one yet.

As in Brandenburg et al. (2008), we use $k_{\rm f}=5$. In the first panel of Fig. 1, $u_{\rm rms}$ is shown in blue and $B_{\rm rms}$ in red. As in Singh et al. (2017), $u_{\rm rms}$ increases because of shear while $B_{\rm rms}$ saturates around 0.06. This value of $B_{\rm rms}$ remains similar even when ${\rm Pr}_M$ is changed (Figures 2 and 3) or when rotation is added (Figures 4 and 5), but then $u_{\rm rms}$ is smaller and comparable to $B_{\rm rms}$.

$\eta_{\rm t}/\eta$ is well above unity, suggesting that we are in a fully turbulent and nonlinear regime. Here, η_{11} and η_{22} are shown in red and blue, respectively. We reset $b^{\rm T}$ in regular time intervals ($\Delta t=100$) and show only those times where the amplitude of $b^{\rm T}$ is above some threshold. η_{yx} is typically close to zero.

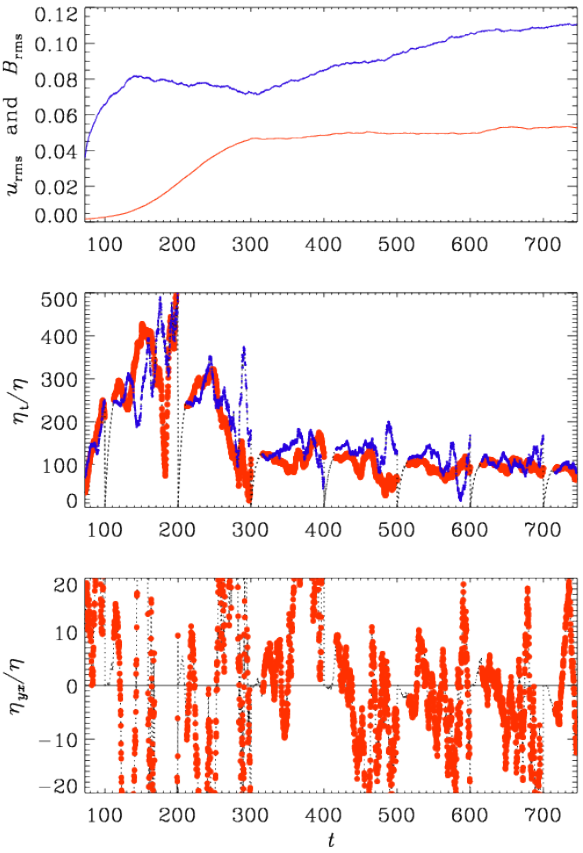

Figure 1: `peta_MOxJ288b` $u_{\rm rms}=0.1$, $S=-0.1$, $\eta=5\times10^{-5}$, $\nu=10^{-3}$, ${\rm Re}=20$, $R_{\rm m}=400$.

2 Models with shear and rotation

There are two models where rotation ($\Omega>0$) is included (Figures 4 and 5). This should help making η_{yx} more negative, but this didn't seem to happen.

References

Brandenburg, A., Rädler, K.-H., Rheinhardt, M., & Käpylä, P. J. 2008, ApJ, 676, 740

Singh, N. K., Rogachevskii, I., & Brandenburg, A. 2017, PRL, submitted 1610.07215

Squire, J., & Bhattacharjee, A. 2016, J. Plasma Phys., 82, 535820201

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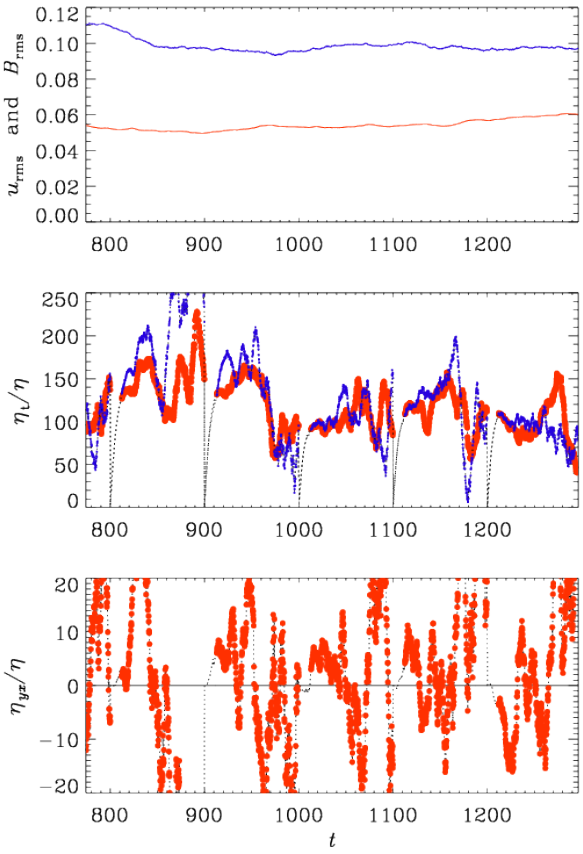

Figure 2: `peta_M0xJ288c` $u_{\rm rms} = 0.1$, $S = -0.1$, $\eta = 5 \times 10^{-5}$, $\nu = 5 \times 10^{-4}$, Re $= 40$, $R_{\rm m} = 400$.

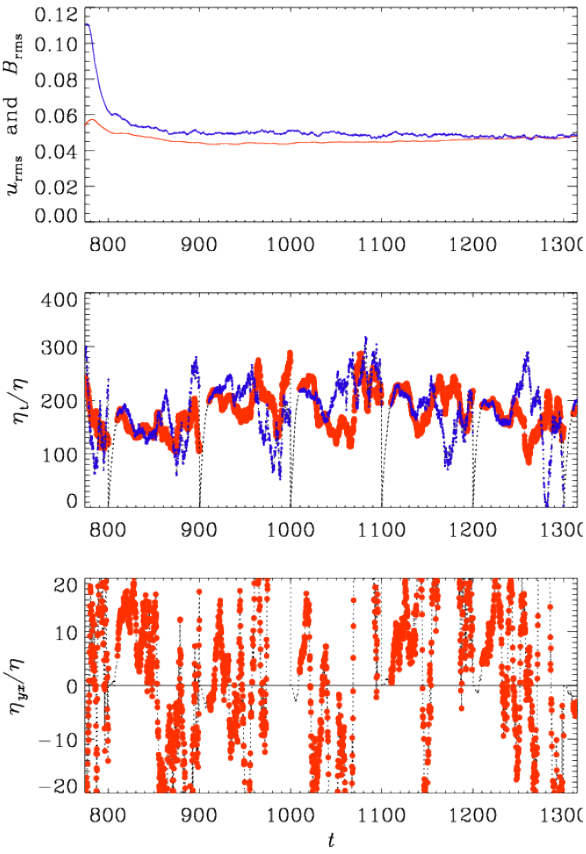

Figure 3: `peta_M0xJ288d` $u_{\rm rms} = 0.05$, $S = -0.1$, $\eta = 2 \times 10^{-5}$, $\nu = 2 \times 10^{-4}$, Re $= 50$, $R_{\rm m} = 500$.

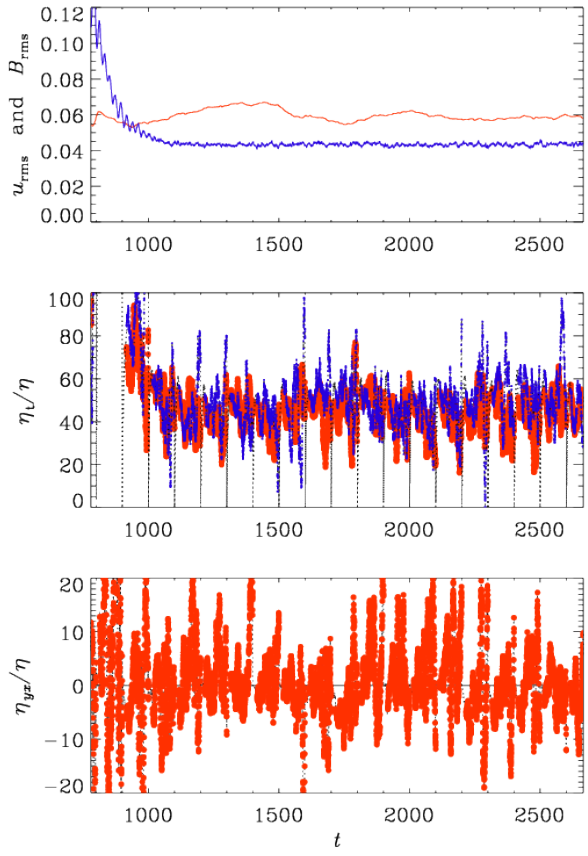

Figure 4: `peta_M0xJ288b_Om01` $u_{\rm rms} = 0.05$, $S = -0.1$, $\Omega = 0.1$, $\eta = 2\times10^{-5}$, $\nu = 1\times10^{-3}$, Re $= 11$, $R_{\rm m} = 220$.

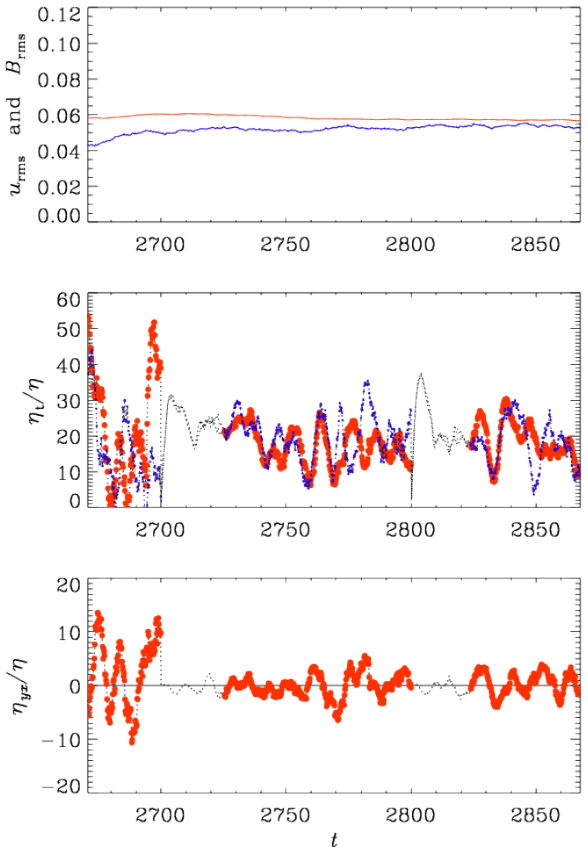

Figure 5: `peta_M0xJ288b_Om05` $u_{\rm rms} = 0.05$, $S = -0.1$, $\Omega = 0.5$, $\eta = 2\times10^{-5}$, $\nu = 1\times10^{-3}$, Re $= 11$, $R_{\rm m} = 220$.