On the edge of an inverse cascade

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In many dynamical systems in nature energy cascades forward or inversely in scale space. In three dimensional fluid turbulence energy cascades forward from large to small scales while in two dimensional turbulence energy cascades inversely from small scales to large scales. There are some examples however that have a mixed behavior such as fast rotating fluids and conducting fluids in the presence of strong magnetic fields or flows in constrained geometry. We expect then a critical amplitude of the control parameter (rotation rate/magnetic field/aspect ratio) for which the flow transitions from one case to the other. Here we present a study of a simpler system that is computationally tractable and exhibits the same behavior : 2D-MHD. In the absence of any external magnetic field or magnetic forcing any zero-average magnetic field fluctuations that exist at t=0 in 2D-MHD will die out (due to the anti-dynamo theorem of 2D flows) and the system will reduce to ordinary 2D fluid turbulence with an inverse energy cascade. If however there is a sufficiently strong uniform magnetic field or an electro-motive force in the system that act as a source of magnetic energy the flow will sustain magnetic field fluctuations and the flow become magnetic dominated with a forward energy cascade. Thus this 2d system also exhibits a dual cascade controlled by the amplitude of the magnetic forcing. We present the results of an investigation that studies the transition from forward to inverse cascade using direct numerical simulations and simplified models.