

# 具有平均磁场和旋转的湍动磁流体横螺度发电机

杨焱<sup>\*† 55</sup>, 朱建州<sup>† 56</sup>,

<sup>\*</sup> 中国科学院力学研究所, 高温气体动力学国家重点实验室, 北京, 100190

<sup>†</sup>南京市高淳区速诚基础与交叉科学研究中心, 高淳, 南京 211316

在天体物理中大尺度磁场的产生和维持需要合适的发电机。Frisch et al. [J. Fluid Mech. 68, 769 (1975).] 和 Pouquet et al. [J. Fluid Mech. 73, 1769 (1976).] 提出将相关的发电机理论, 表述为当没有背景磁场  $B_0$  或旋转  $\Omega_0$  时的磁螺旋度的反级串。近期, 朱建州等的工作[J. Fluid. Mech. 739, 479 (2014)] 将该反级串解释为单一手性扇区占优态(once chiral sector dominated state(s)), 即与绝对平衡态谱的两个手性扇区之一的小波数极点相关: 其中的动力学采用了螺旋模(波)分解技术进行手性分解。天体物理研究对象通常受到背景磁场  $B_0$  或旋转  $\Omega_0$  的作用, 导致磁螺旋(对应于  $B_0$ )和横螺度(对应于  $\Omega_0$ )的守恒性被破坏, 但是此时可引入新的被称为平行螺度的不变量, 它是磁螺旋度和横螺度的一种线性组合[Shebalin, J. Plasma Physics 72, 507 (2006)]. 通过对 Shebalin 所给的信息仔细观察朱建州等的谱表达式, 认为存在一种磁流体动力学内秉的横螺度发电机[Yokoi, Geophysical & Astrophysical Fluid Dynamics 107 (2013)], 即可能有以下事实: 平行螺度同时向大尺度和小尺度级串时, (在小尺度) 注入的横螺度“内部”转化为(较)大尺度的磁螺旋度。本文通过直接数值模拟检验上述猜想, 利用我们修改后的 Pencil 数值程序 [<http://pencil-code.nordita.org/>] 实现网格数高达  $1024^3$  的不同工况的模拟进行比较分析。

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<sup>3</sup> 助理研究员, yangyang@imech.ac.cn

<sup>4</sup> (田园学派后院)院士, jz@sccfis.org, 通信作者

# Cross-helicity dynamo of turbulent MHD with background magnetic field and rotation

Yan YANG<sup>\*</sup><sup>†53</sup> and Jian-Zhou ZHU<sup>†54</sup>

<sup>\*</sup>*LHD, Institute of Mechanics, Chinese Academy of Sciences, Beijing, 100190, China*

<sup>†</sup>*Su-Cheng Centre for Fundamental and Interdisciplinary Sciences, Gaochun, Nanjing 211316, China*

The generation and maintenance of large scale dynamo in astrophysics requires an appropriate dynamo theory. A relevant magnetohydrodynamic (MHD) turbulence theory was proposed by Frisch et al. [[J. Fluid Mech. 68, 769 \(1975\)](#).] and Pouquet et al. [[J. Fluid Mech. 73, 1769 \(1976\)](#).], presenting, for the case with neither background magnetic field  $B_0$  nor rotation  $\Omega_0$ , inverse cascade of magnetic helicity, which has recently been clarified by Zhu et al. [[J. Fluid. Mech. 739, 479-501 \(2014\)](#)] to be once chiral sector dominated state(s) - OCSDS – relevant to the small wavenumber pole of one of the two chiral sectors of the absolute equilibrium spectra: the dynamics is chirally decomposed with the technique of helical mode/wave decomposition. However, astrophysical objects are in general subject to a background magnetic field  $B_0$  and rotation  $\dot{U}_0$ , with the breaking down of the conservation of magnetic helicity (due to  $B_0$ ) and cross-helicity (due to  $\Omega_0$ ) but with a new invariance called parallel helicity as the particular linear combination of the magnetic helicity and cross-helicity [[J. V. Shebalin, J. Plasma Physics 72, 507 \(2006\)](#)]. Now, a careful observation of the spectra given by Zhu et al. with the input of the information given by Shebalin still suggests that there could be a way to have cross-helicity dynamo [[N. Yokoi, Geophysical & Astrophysical Fluid Dynamics 107\(2013\)](#)] genuinely through the intrinsic dynamcis of MHD: there is a possibility in such a situation that the [injected (at smaller scales)] cross-helicity genuinely convert into magnetic helicity at large(r) scales, while the parallel helicity cascades simultaneously to both large and small scales. The above conjecture is tested with the application of our modification of the Pencil code [<http://pencil-code.nordita.org/>], with simulations using grid numbers up to  $1024^3$  for various conditions.

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<sup>53</sup> Assistant Professor, yangyan@imech.ac.cn

<sup>54</sup> (Academy-of-TianYuanXuePai)Academician, jz@sccfis.org, Correspondence Author