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Generation of magnetic field by dynamo action in a turbulent flow of liquid sodium

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Industrial dynamos routinely generate currents and magnetic fields from mechanical motions. In these devices, pioneered by Siemens, the path of the electrical currents and the geometry of the rotors are completely prescribed. As it cannot be the case for planets and stars, experiments aimed at studying dynamos in the laboratory have evolved towards relaxing these constraints. Solid rotor experiments showed that a dynamo state could be reached with prescribed motions but currents free to self-organize. A landmark was reached in 2000, when the experiments in Riga and Karlsruhe showed that fluid dynamos could be generated by organizing favourable sodium flows, the electrical currents being again free to self-organize. For these experiments, the self-sustained dynamo fields had simple time dynamics (a steady field in Karlsruhe and an oscillatory field in Riga). No further dynamical regimes where reached. We report the observation of dynamo action in swirling flows for which turbulence is fully developed. The flows are generated in the gap between counter-rotating impellers (the von Karman Sodium experiment -VKS). Dynamo action is reached at magnetic Reynolds number Rm$\approx$30. When the impellers are rotating at equal rates, the dynamo field is statistically steady, although the rms fluctuation level is of the order of the mean amplitude. For impellers rotated at different speeds, a variety of dynamical regimes are observed, including magnetic field reversals. We will describe and discuss the features of these dynamos, including the nature of the bifuraction, the scaling of the self-sustained fields, the excess mechanical power, etc. Some regimes have geomorphic characteristics, while others may be relevant in the astrophysical context.