Review

Realistic MHD simulations of the solar atmosphere

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Realistic simulations of the solar photosphere date back almost three decades. While the physical ingredients in terms of compressible MHD, a realistic equation of state and 3D radiative transfer have remained mostly unchanged, tremendous progress since then can be mostly attributed to an about million-fold increase of computing power in combination with improvements in code efficiency and robustness. Today about a handful of mostly independent codes are in use in the solar physics community and high resolution simulations have contributed significantly to almost all aspects of photospheric magnetoconvection. In this talk I will give a brief overview of recent developments and focus in particular on: (1) Small-scale dynamo simulations that provide an explanation of quiet sun magnetism, (2) Magneto-convective sunspot models that give a consistent picture of sunspot fine structure from umbral dots to penumbral filaments and light bridges, and (3) Models of flux emergence on scales of active regions that demonstrate the amplification of emerging flux to pores and sunspots including structures such as complex light bridges and penumbrae.