Solenoidal versus compressive turbulence forcing

C. Federrath[1], J. Duval[2], R. S. Klessen[1], W. Schmidt[3] and M.-M. Mac Low[4]

[1]Zentrum für Astronomie der Universität Heidelberg, Institut für Theoretische Astrophysik, Albert-Ueberle-Str. 2, D-69120 Heidelberg, Germany

[2]Astronomy Department at Boston University, 725 Commonwealth Avenue, Boston, MA 02215, USA

[3]Institut für Astrophysik Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

[4]Department of Astrophysics, American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024-5192, USA

Abstract. We analyze the statistics and star formation rate obtained in high-resolution numerical experiments of forced supersonic turbulence, and compare with observations. We concentrate on a systematic comparison of solenoidal (divergence-free) and compressive (curl-free) forcing (Federrath *et al.* 2009 a,b), which are two limiting cases of turbulence driving. Our results show that for the same RMS Mach number, compressive forcing produces a three times larger standard deviation of the density probability distribution. When self-gravity is included in the models, the star formation rate is more than one order of magnitude higher for compressive forcing than for solenoidal forcing.

Keywords. hydrodynamics – ISM: clouds – ISM: structure – methods: statistical – turbulence

Observational data indicate that turbulence in the ISM exhibits both signatures of solenoidal and compressive forcing, depending on the region under consideration (Heyer *et al.* 2006; Hily-Blant *et al.* 2008; Goodman *et al.* 2009). In particular, expanding shells show statistical characteristics similar to compressively driven turbulence.

Compressive forcing produces a three times larger standard deviation of the three-dimensional and the column density probability distributions (PDFs) for the same RMS Mach number (Federrath *et al.* 2008). When self-gravity is added to the models, the star formation rate is about 25 times higher for compressive forcing. These two results demonstrate that star formation models based on the turbulent density PDF (Padoan & Nordlund 2002; Krumholz & McKee 2005; Elmegreen 2008; Hennebelle & Chabrier 2009) must take the nature of the turbulence forcing into account.

References

Elmegreen, B. G. 2008, *ApJ*, 672, 1006
Federrath, C., Duval, J., Klessen, R. S., Schmidt, W., & Mac Low, M.-M. 2009a, *arXiv*:0905.1060
Federrath, C., Klessen, R. S., & Schmidt, W. 2008, *ApJ*, 688, L79
Federrath, C., Klessen, R. S., & Schmidt, W. 2009b, *ApJ*, 692, 364
Goodman, A. A., Pineda, J. E., & Schnee, S. L. 2009, *ApJ*, 692, 91
Hennebelle, P. & Chabrier, G. 2009, *ApJ*, 702, 1428
Heyer, M. H., Williams, J. P., & Brunt, C. M. 2006, *ApJ*, 643, 956
Hily-Blant, P., Falgarone, E., & Pety, J. 2008, *A&A*, 481, 367
Krumholz, M. R. & McKee, C. F. 2005, *ApJ*, 630, 250
Padoan, P., & Nordlund, Å. 2002, *ApJ*, 576, 870