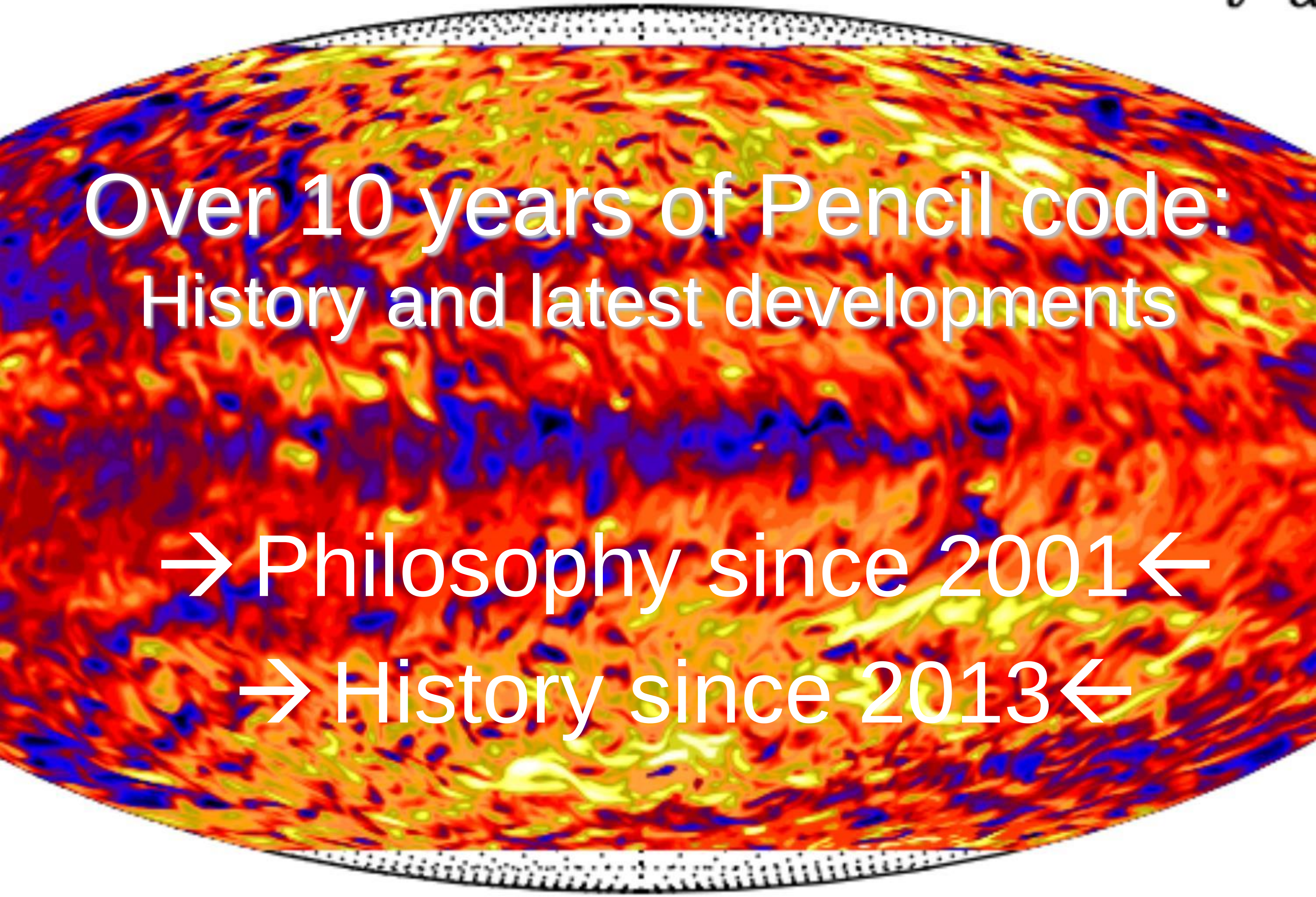
Over 10 years of Pencil code:

History and latest developments

→ Philosophy since 2001←

→ History since 2013←



Pencil Code Philosophy

- Maximum freedom
  - Alternatives possible
- Research-driven
  - Can’t expect service
- Minimum ties
  - Acknowledge development work of others
- Only one version
  - Minimal duplication

License agreement and giving credit

The content of all files under `:pserver:$USER@svn.nordita.org:/var/cvs/brandenb` are under the GNU General Public License (`http://www.gnu.org/licenses/gpl.html`).

We, the PENCIL CODE community, ask that in publications and presentations the use of the code (or parts of it) be acknowledged with reference to the web site `http://www.nordita.org/software/pencil-code/`. As a courtesy to the people involved in developing particularly important parts of the program (use `svn annotate src/*.f90` to find out who did what!) we suggest to give appropriate reference to one or several of the following papers (listed here in temporal order):

Dobler, W., Haugen, N. E. L., Yousef, T. A., & Brandenburg, A.: 2003, "Bottleneck effect in three-dimensional turbulence simulations," *Phys. Rev.* **E 68**, 026304, 1-8 (astro-ph/0303324)

Haugen, N. E. L., Brandenburg, A., & Dobler, W.: 2003, "Is nonhelical hydromagnetic turbulence peaked at small scales?" *Astrophys. J. Lett.* **597**, L141-L144 (astro-ph/0303372)

Brandenburg, A., Käpylä, P., & Mohammed, A.: 2004, "Non-Fickian diffusion and tau-approximation from numerical turbulence," *Phys. Fluids* **16**, 1020-1027 (astro-ph/0306521)

Johansen, A., Andersen, A. C., & Brandenburg, A.: 2004, "Simulations of dust-trapping vortices in protoplanetary discs," *Astron. Astrophys.* **417**, 361-371 (astro-ph/0310059)

Haugen, N. E. L., Brandenburg, A., & Mee, A. J.: 2004, "Mach number dependence of the onset of dynamo action," *Monthly Notices Roy. Astron. Soc.* **353**, 947-952 (astro-ph/0405453)

Free licence, but giving credit to research

Brandenburg, A., Rädler, K.-H., Rheinhardt, M., & Käpylä, P. J.: 2008, "Magnetic diffusivity tensor and dynamo effects in rotating and shearing turbulence," *Astrophys. J.* **676**, 740-751 (arXiv/0710.4059)

Lyra, W., Johansen, A., Klahr, H., & Piskunov, N.: 2008, "Embryos grown in the dead zone. Assembling the first protoplanetary cores in low-mass selfgravitating circumstellar disks of gas and solids," *Astron. Astrophys.* **491**, L41-L44

Lyra, W., Johansen, A., Klahr, H., & Piskunov, N.: 2009, "Standing on the shoulders of giants. Trojan Earths and vortex trapping in low-mass selfgravitating protoplanetary disks of gas and solids," *Astron. Astrophys.* **493**, 1125-1139

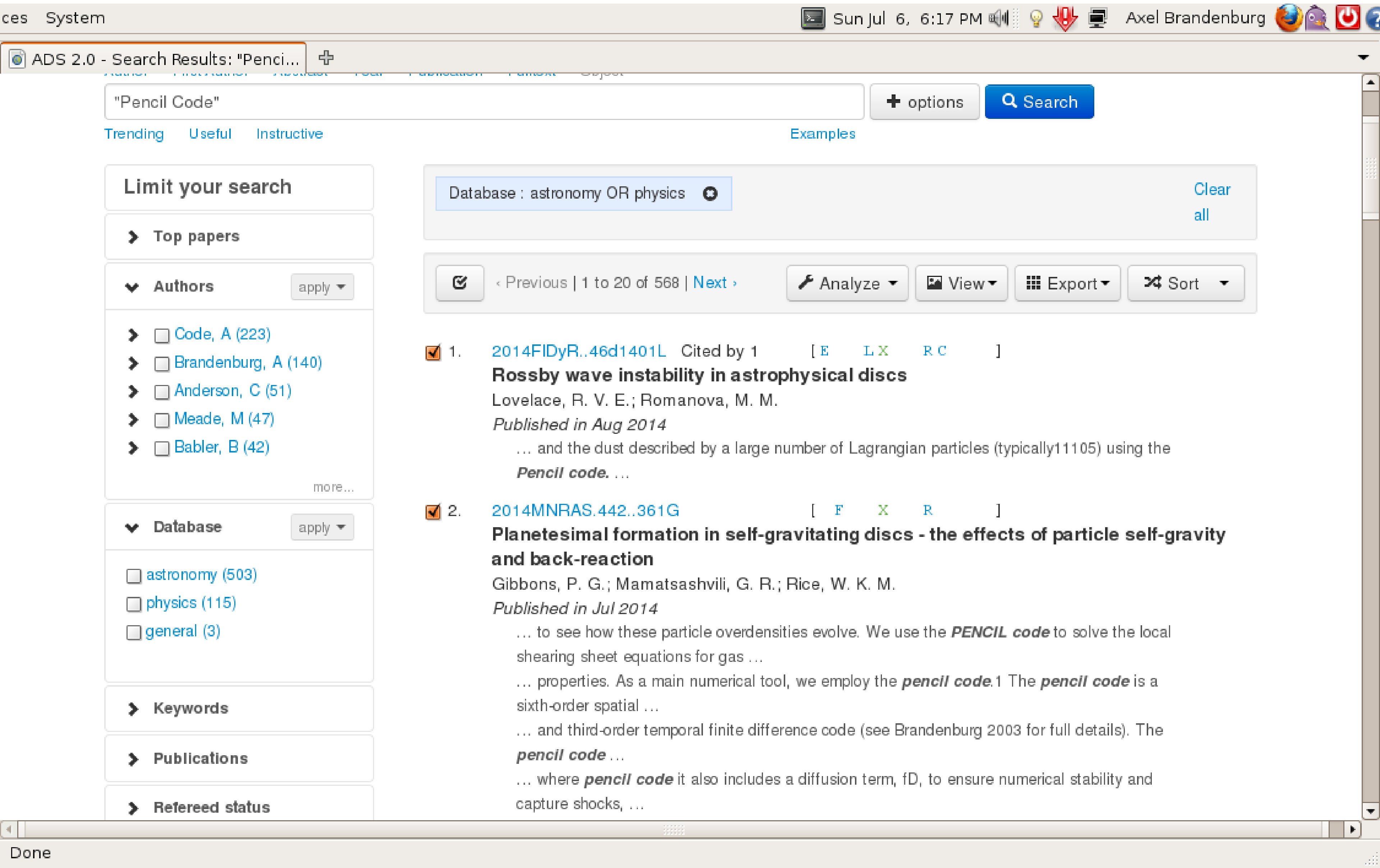
Lyra, W., Johansen, A., Zsom, A., Klahr, H., & Piskunov, N.: 2009, "Planet formation bursts at the borders of the dead zone in 2D numerical simulations of circumstellar disks," *Astron. Astrophys.* **497**, 869-888 (arXiv/0901.1638)

Mitra, D., Tavakol, R., Brandenburg, A., & Moss, D.: 2009, "Turbulent dynamos in spherical shell segments of varying geometrical extent," *Astrophys. J.* **697**, 923-933 (arXiv/0812.3106)

Haugen, N. E. L., & Kragset, S.: 2010, "Particle impaction on a cylinder in a crossflow as function of Stokes and Reynolds numbers," *J. Fluid Mech.* **661**, 239-261

Rheinhardt, M., & Brandenburg, A.: 2010, "Test-field method for mean-field coefficients with MHD background," *Astron. Astrophys.* **520**, A28 (arXiv/1004.0689)

Using ADSlab; search for “Pencil Code”



Assemble bibtex file

Scientific usage of the PENCIL CODE

Search results using http://adslabs.org

July 6, 2014

A search using http://adslabs.org indicates the papers where the PENCIL CODE is being quoted. In the following we quote the papers that are directly making use of the code either for their own scientific work of those authors, or for code comparison purposes. We include conference proceedings, which make about 15–20% of all papers. We classify the references by year and by topic, although the topics are often overlapping. The primary application of the PENCIL CODE lies in astrophysics, in which case we classify mostly by the field of research.

1 Papers by year

As of July 2014, the PENCIL CODE has been used for a total of 355 research papers.

19 times in 2014 (Gibbons et al., 2014a; Pan et al., 2014; Lyra, 2014; Bhat et al., 2014; Losada et al., 2014; Rheinhardt et al., 2014; Mitra et al., 2014; Turner et al., 2014; Jabbari et al., 2014; Brandenburg and Stepanov, 2014; Chian et al., 2014; Brandenburg, 2014; Gibbons et al., 2014b; Brandenburg et al., 2014; Park, 2014; Käpylä et al., 2014; Modestov et al., 2014; Cole et al., 2014; Rüdiger and Brandenburg, 2014),

51 times in 2013 (Lyra and Kuchner, 2013; Warnecke et al., 2013c; Barekat and Branden-

2 Papers by topic

The PENCIL CODE has been used for the following research topics

1. **Interstellar and intercluster medium as well as early Universe**

   (a) *Interstellar and intercluster medium* (Chamandy et al., 2013; Gent et al., 2013a,b; Bykov et al., 2013; Yang and Krumholz, 2012; Mantere and Cole, 2012; Rogachevskii et al., 2012; Ruoskanen et al., 2011; Piontek et al., 2009; Ruszkowski et al., 2008, 2007; Brandenburg et al., 2007b; Gustafsson et al., 2007, 2006; Brandenburg et al., 2005a; Haugen et al., 2004b; Brandenburg et al., 2003).

   (b) *Small-scale dynamos and reconnection* (Bhat and Subramanian, 2013; Brandenburg, 2011c; Baggaley et al., 2009, 2010; Schekochihin et al., 2005, 2007; Haugen and Brandenburg, 2004b; Haugen et al., 2004c,a, 2003; Dobler et al., 2003).

   (c) *Primordial magnetic fields and decaying turbulence* (Brandenburg et al., 2014; Kahniashvili et al., 2012, 2013; Tevzadze et al., 2012; Candelaresi and Brandenburg, 2011a; Kahniashvili et al., 2010; Del Sordo et al., 2010; Christensson et al., 2005; Yousef et al., 2004).

2. **Planet formation and inertial particles**

   (a) *Planet formation* (Gibbons et al., 2014b; Turner et al., 2014; Gibbons et al., 2014a; Lyra and Kuchner, 2013; Dittrich et al., 2013; Gibbons et al., 2012; Hubbard, 2012; Horn et al., 2012; Lyra and Kuchner, 2012; Yang et al., 2012; Lambrechts and Johansen, 2012; Johansen et al., 2012; Fromang et al., 2011; Johansen et al., 2011; Lyra and Klahr, 2011; Lyra et al., 2010; Johansen and

Bhat, P. and Subramanian, K. (2013). Fluctuation dynamos and their Faraday rotation signatures. *Month. Not. Roy. Astron. Soc.*, 429:2469–2481.

Bingert, S. and Peter, H. (2011). Intermittent heating in the solar corona employing a 3D MHD model. *Astron. Astrophys.*, 530:A112.

Bingert, S. and Peter, H. (2013). Nanoflare statistics in an active region 3D MHD coronal model. *Astron. Astrophys.*, 550:A30.

Bingert, S., Zacharias, P., Peter, H., and Gudiksen, B. V. (2010). On the nature of coronal loops above the quiet sun network. *Advances in Space Research*, 45:310–313.

Bonanno, A., Brandenburg, A., Del Sordo, F., and Mitra, D. (2012). Breakdown of chiral symmetry during saturation of the Tayler instability. *Phys. Rev. E*, 86(1):016313.

Børve, S., Speith, R., and Trulsen, J. (2009). Numerical Dissipation in RSPH Simulations of Astrophysical Flows with Application to Protoplanetary Disks. *Astrophys. J.*, 701:1269–1282.

Bourdin, P.-A., Bingert, S., and Peter, H. (2013a). 3D-MHD model of a solar active region corona (Bourdin+, 2013). *VizieR Online Data Catalog*, 355:59123.

Bourdin, P.-A., Bingert, S., and Peter, H. (2013b). Observationally driven 3D magnetohydrodynamics model of the solar corona above an active region. *Astron. Astrophys.*, 555:A123.

Brandenburg, A. (2003). *Computational aspects of astrophysical MHD and turbulence*, pages 269–344.

Brandenburg, A. (2005a). Distributed versus tachocline dynamos. *ArXiv Astrophysics e-prints*.

The Pencil Code

a high-order finite-difference code for compressible MHD

Highlights

The document about the **Scientific Usage of the Pencil Code** lists currently 352 research papers quoting the Pencil Code.

Currently, we have the following highlights planned:

- **Helical MHD Dynamo** [AB]
- Isotropic turbulence [AB]
- Stellar convection [BD/DB]
- Magnetorotational instability [AJ]
- Streaming instability [DC/ML/AJ]
- Global cartesian discs [WL]
- Particle flow around objects [NH/DM]

This is a test page / template for the highlights subdirectory.

ODUCTION
YSICAL BACKGROU
MERICAL SETUP
SULTS
Saturation Values a

tract1.png

tract1.png
act1.png

tract2.png

act2.png

1.png

It is important that thermal cooling and diffusion times are in the right regime

We model h separately beca or the other don the shorter time ambient gas.

Reference via footnote

and thermal equilibration with the irradiation from the central object) terms on the right hand side of the entropy equation. As e diffusion coefficient), constant and define tex has a radius of H, diffusion time τ_{diff} has the value we quote in, e.g., Table 1. If the vortex is smaller than H relaxation will be much faster.

3. NUMERICAL SETUP

Our simulations were conducted with the PENCIL CODE.[6] We use a two-dimensional, local shearing sheet approach. We consider a sheet in the mid-plane that co-rotates with the co-rotational radius R_0. This is a 2D version of the model used in Lyra & Klahr (2011). To include the baroclinic term they define a global entropy gradient β. Note that in our approximation the gradients for entropy (s) and pressure (p) are the same. Therefore we do not distinguish between them in our notation and call both β. However, in real disks both may easily differ.

The total pressure $p_{\mathrm{tot}} = \bar{p} + p$ consist of a local fluctuation p and a time-independent part that follows a large scale radial pressure gradient β

$$\bar{p} = p_0 (r/R_0)^{-\beta}, \tag{4}$$

where r is the cylindrical radius. The full set of linearized equations used in our simulations is

$$\frac{\mathcal{D}\rho}{\mathcal{D}t} + (\boldsymbol{u}\cdot\nabla)\,\rho = -\rho\nabla\cdot\boldsymbol{u} + f_D(\rho) \tag{5}$$

$$\frac{\mathcal{D}\boldsymbol{u}}{\mathcal{D}t} + (\boldsymbol{u}\cdot\nabla)\,\boldsymbol{u} = -\frac{1}{\rho}\nabla p - 2\Omega_0(\hat{z}\times\boldsymbol{u}) + \frac{3}{2}\Omega_0 u_x\,\hat{y} + \frac{\beta p_0}{R_0}\left(\frac{1}{\rho} - \frac{1}{\rho_0}\right)\hat{x} + f_\nu(\boldsymbol{u},\rho) \tag{6}$$

$$\frac{\mathcal{D}s}{\mathcal{D}t} + (\boldsymbol{u}\cdot\nabla)\,s = \frac{1}{\rho T}\left\{\nabla\cdot(K\nabla T) - \rho c_v\frac{(T-T_0)}{\tau_{\mathrm{cool}}} + \frac{\beta p_0}{R_0}\frac{u_x}{(\gamma-1)}\right\} + f_K(s). \tag{7}$$

To clarify that it is indeed the global entropy gradient that produces the vorticity, we take the curl of the Navier–Stokes Equation (6) and assume an equilibrium state, $u_x = 0$, and $\nabla P = \mathbf{0}$ so that

$$\frac{\mathcal{D}\omega_z}{\mathcal{D}t} = \frac{\beta p_0}{\rho^2 R_0}\partial_y \rho. \tag{9}$$

Here we see that the negative azimuthal density gradient across the vortex is the source for vorticity production proportional to the global entropy gradient.

Shearing sheet simulations with Zeus[7] like finite volume codes without explicit viscosity, e.g., the TRAMP code, have shown a weak amplification of kinetic energy for the pure adiabatic case, i.e., infinite cooling time (Klahr 2013, private communication). This numerical artifact does not occur with simulations performed by the PENCIL CODE. See the Appendix for a one-dimensional (1D) radial test/comparison simulation.

Initially we apply a finite perturbation in the density so that

$$\rho\,(x,y) = \rho_0 + \rho' \tag{10}$$

with ρ_0 the constant background density and ρ' the actual perturbation of the form

$$\rho' = \rho_0 C e^{-(x/2\sigma)^2} \times \sum_{i=-k_x}^{k_x}\sum_{j=0}^{k_y}\sin\left\{2\pi\left\{i\frac{x}{L_x} + j\frac{y}{L_y} + \phi_{ij}\right\}\right\},$$

where C describes the strength of the perturbation. We perturb the density in a way that $\rho_{\mathrm{rms}} = 5\%$ for $\beta = 1.0, 2.0$ (runs A–I) and $\rho_{\mathrm{rms}} = 10\%$ for $\beta = 0.5$ (runs J-P). To achieve a random perturbation we apply an arbitrary phase ϕ_{ij} between 0 and 1. The initial state is non-vortical. Again, this is the identical initial condition as used in Lyra & Klahr (2011) as well as the same amplitude, C, for simulations with $\beta = 2.0$, as was used in their simulations.

[6] See http://www.nordita.org/software/pencil-code/

[7] http://www.astro.princeton.edu/~jstone/zeus.html

1	2012sf2a.conf..329F	1.000	12/2012	A		F			R		U
	Félix, S.; Audit, E.; Dintrans, B.	Pulsations-convection combination in stars									
2	2012MNRAS.426.1444G	1.000	10/2012	A	E	F	L	X	R	C	U
	Gibbons, P. G.; Rice, W. K. M.; Mamatsashvili, G. R.	Planetesimal formation in self-gravitating discs									
3	2012ApJ...756...62L	1.000	09/2012	A	E	F	L	X	R	C	U
	Lyra, Wladimir; Mac Low, Mordecai-Mark	Rossby Wave Instability at Dead Zone Boundaries in Three-dimensional Resistive Magnetohydrodynamical Global Models of Protoplanetary Disks									
4	2012PhDT........18M	1.000	08/2012	A	E	F				C	U
	McNally, Colin P.	A Meshless Method for Magnetohydrodynamics and Applications to Protoplanetary Disks									
5	2012ApJS..201...18M	1.000	08/2012	A	E	F	L	X	R	C	U
	McNally, Colin P.; Lyra, Wladimir; Passy, Jean-Claude	A Well-posed Kelvin-Helmholtz Instability Test and Comparison									
6	2011ESS.....2.3302L	1.000	09/2011	A							
	Lambrechts, Michiel	Growth of Gas-giant Cores in Protoplanetary Discs									

Title:	Planetesimal formation in self-gravitating discs
Authors:	Gibbons, P. G.; Rice, W. K. M.; Mamatsashvili, G. R.
Affiliation:	AA(SUPA, Institute for Astronomy, Royal Observatory, Blackford Hill Edinburgh, EH9 3HJ), AB(SUPA, Institute for Astronomy, Royal Observatory, Blackford Hill Edinburgh, EH9 3HJ), AC(INAF, Osservatorio Astronomico di Torino, via Osservatorio 20 Pino Torinese, 10025 Italy; Faculty of Exact and Natural Sciences, Tbilisi State University, Il. Chavchavadze ave. 1 Tbilisi, 0128 Georgia)
Publication:	Monthly Notices of the Royal Astronomical Society, Volume 426, Issue 2, pp. 1444-1454. (MNRAS Homepage)
Publication Date:	10/2012
Origin:	WILEY
Astronomy Keywords:	accretion, accretion discs, gravitation, hydrodynamics, instabilities, planets and satellites: formation
DOI:	10.1111/j.1365-2966.2012.21731.x
Bibliographic Code:	2012MNRAS.426.1444G

Abstract

We study particle dynamics in local two-dimensional simulations of self-gravitating accretion discs with a simple cooling law. It is well known that the structure which arises in the gaseous component of the disc due to a gravitational instability can have a significant effect on the evolution of dust particles. Previous results using global simulations indicate that spiral density waves are highly efficient at collecting dust particles, creating significant local overdensities which may be able to undergo gravitational collapse. We expand on these findings using a range of cooling times to mimic the conditions at a large range of radii within the disc. Here we use the PENCIL code to solve the 2D local shearing sheet equations for gas on a fixed grid together with the equations of motion for solids coupled to the gas solely through aerodynamic drag force. We find that spiral density waves can create significant enhancements in the surface density of solids, equivalent to 1-10 cm sized particles in a disc following the profiles of Clarke around an ˜1 $M_{\odot}$ star, causing it to reach concentrations

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pencil-code

A high-order finite-difference code for compressible hydrodynamic flows with magnetic fields and particles

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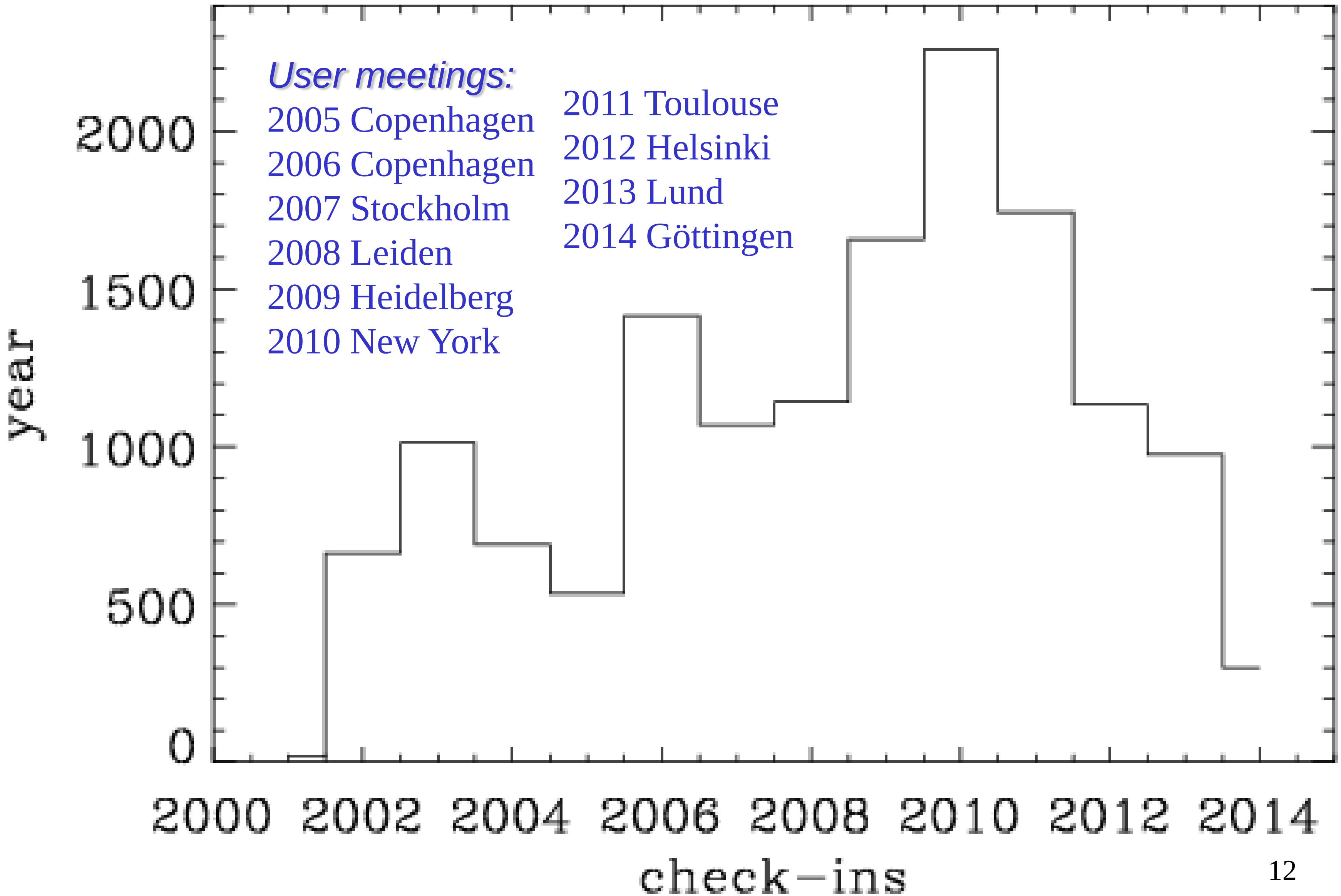
Checkout | Browse | **Changes** | Request code review

Committed Changes 21876 - 21852 of 21876 Older ›

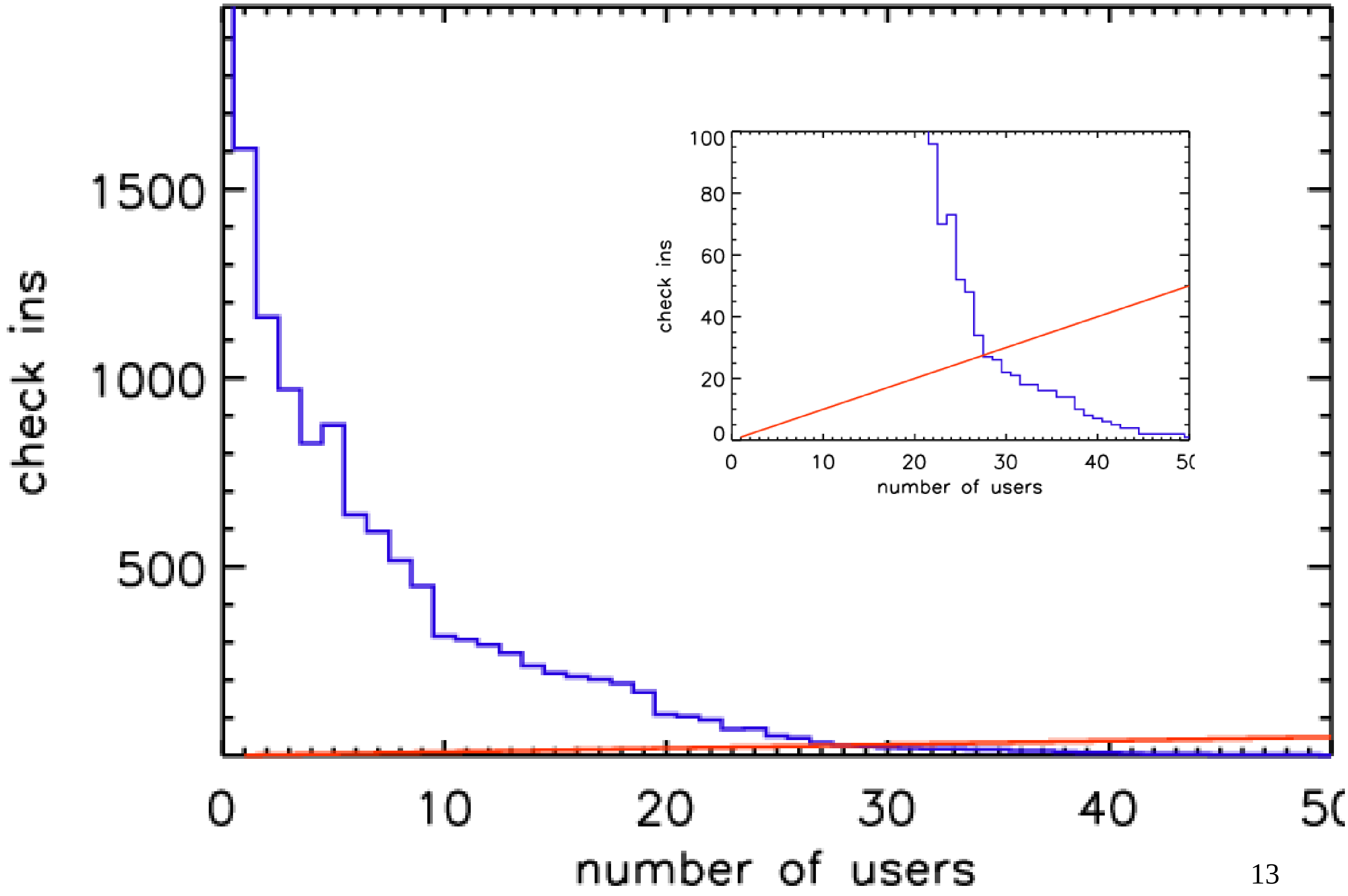
	Rev	Scores	Commit log message	Date	Author
★	r21876		replaced minimal nd value of 0 by ndmin_for_mdvar which is initialized by zero.	Today (13 hours ago)	AxelBrandenburg
☆	r21875		minor	Today (14 hours ago)	Nbabkovskaia
☆	r21874		added smoothing of the initial particle profile	Today (15 hours ago)	Nbabkovskaia
☆	r21873		Change the treatment of infinite beta.	Today (15 hours ago)	ccyang@astro.lu.se
☆	r21872		added ACTOS data for initial particle distr.	Yesterday (17 hours ago)	Nbabkovskaia
★	r21871		corrected imd -> imd[0], changed iFrad -> iKR_Frad	Yesterday (23 hours ago)	AxelBrandenburg
☆	r21870		Add yz-averages b2mx, bxbzmx, and bybzmx.	Yesterday (37 hours ago)	ccyang@astro.lu.se
☆	r21869		polish some bump in the transition from convection zone to corona	Yesterday (37 hours ago)	joern.warnecke
☆	r21868		Add yz-averages betamx and beta2mx.	Yesterday (37 hours ago)	ccyang@astro.lu.se
☆	r21867		Add xy-averages betamz and beta2mz.	Yesterday (37 hours ago)	ccyang@astro.lu.se
☆	r21866		Add pencil betam and diagnostics betam, betamax, and betamin.	Yesterday (38 hours ago)	ccyang@astro.lu.se
☆	r21865		Small correction of HTML code.	Jun 10 (42 hours ago)	Bourdin.KIS
☆	r21864		Added reference for the solar corona models.	Jun 10 (42 hours ago)	Bourdin.KIS
★	r21863		automatic validation completed: auto-test on norlx51b by	Jun 10 (43 hours ago)	AxelBrandenburg
☆	r21862		new setting of ACTOS problem	Jun 9 (2 days ago)	Nbabkovskaia
★	r21861		automatic validation completed: auto-test on norlx51b by	Jun 9 (2 days ago)	AxelBrandenburg
☆	r21860		Now included corrections in Hminus Opacity with switch lHminus_opacity_correctior	Jun 9 (2 days ago)	palvi.b
★	r21859		minor correction in forcing, missing argument argument, and an addition to mean-	Jun 8 (3 days ago)	AxelBrandenburg

Rate of src/ check-ins



12

H-index of check-ins



Automatic validation tests

Pencil Code -- Tests

Automatic test results

To ensure reproducability, the Pencil Code is tested daily for a number of sample applications. This is important for us in order to make sure certain improvements in some parts of the code do not affect the functionality of other parts. For other users who suspect that a new problem has emerged it could be useful to first see whether this problem also shows up in our own tests. The latest test results for a can be seen online:

- opto3 (Linux on 4 x Opteron 2.2GB, ifort 9.1 compiler with MPICH, by Anders Johansen)
- GNU Fortran (Ubuntu 4.4.1-4ubuntu9) 4.4.1 (by Philippe Bourdin)
- Shal (Linux on 2 x Quadcore Intel Xeon E5320@1.86GHz, ifort 64 bits v11.1.064, by Boris Dintrans, regular level 2 test)
- Shal (Linux on 2 x Quadcore Intel Xeon E5320@1.86GHz, ifort 64 bits v11.1.064, by Boris Dintrans, 16 separate tests)
- Linux/Ubuntu10.4 on Intel Core 2 Quad Q9000@2.00GHz, ifort 64bit v11.1 (Sven Bingert, standard + personal tests)
- Nordita Big Test (norlx51, gfortran, openmpi, by Wolfgang/Axel)
- Nordita Hourly Test (norlx51, gfortran, openmpi, by Wolfgang/Axel)
- Nordita PowerMac (os10, g95, ompi, by Axel) [previous]

Note: before checking in your own changes, you should at least do the very minimal auto-test:

```
pc_auto-test --level=0 --no-pencil-check -C
```

```
/data/bourdin/Korona/Recent/pencil-code/samples/2d-tests/field-loop-fargo: (34/34)
    Compiling..                         ok
        No data directory; generating data -> /tmp/pencil-tmp-philippe-10473
    Starting..                          ok
    Running..                           ok
    Validating results..                ok

----------------------------------------------------------------------
All 34 tests succeeded.
```

```
------------------------------------------------------------------------
### auto-test failed ###
Failed 2 test(s) out of 48:
  /home/brandenb/pencil-weekly-tests/samples/corona (compilation)
  /home/brandenb/pencil-weekly-tests/samples/most-modules (running)

CPU time (including compilation): 02:29:20u 30:35s
Total wall-clock time:            02:56:19 = 01:45:10 + 01:09:12
Maintainers of failed tests: anders/astro:lu:se,wlyra/amnh:org,nbabkovska
```

Wed Apr 6 14:46:39 2011

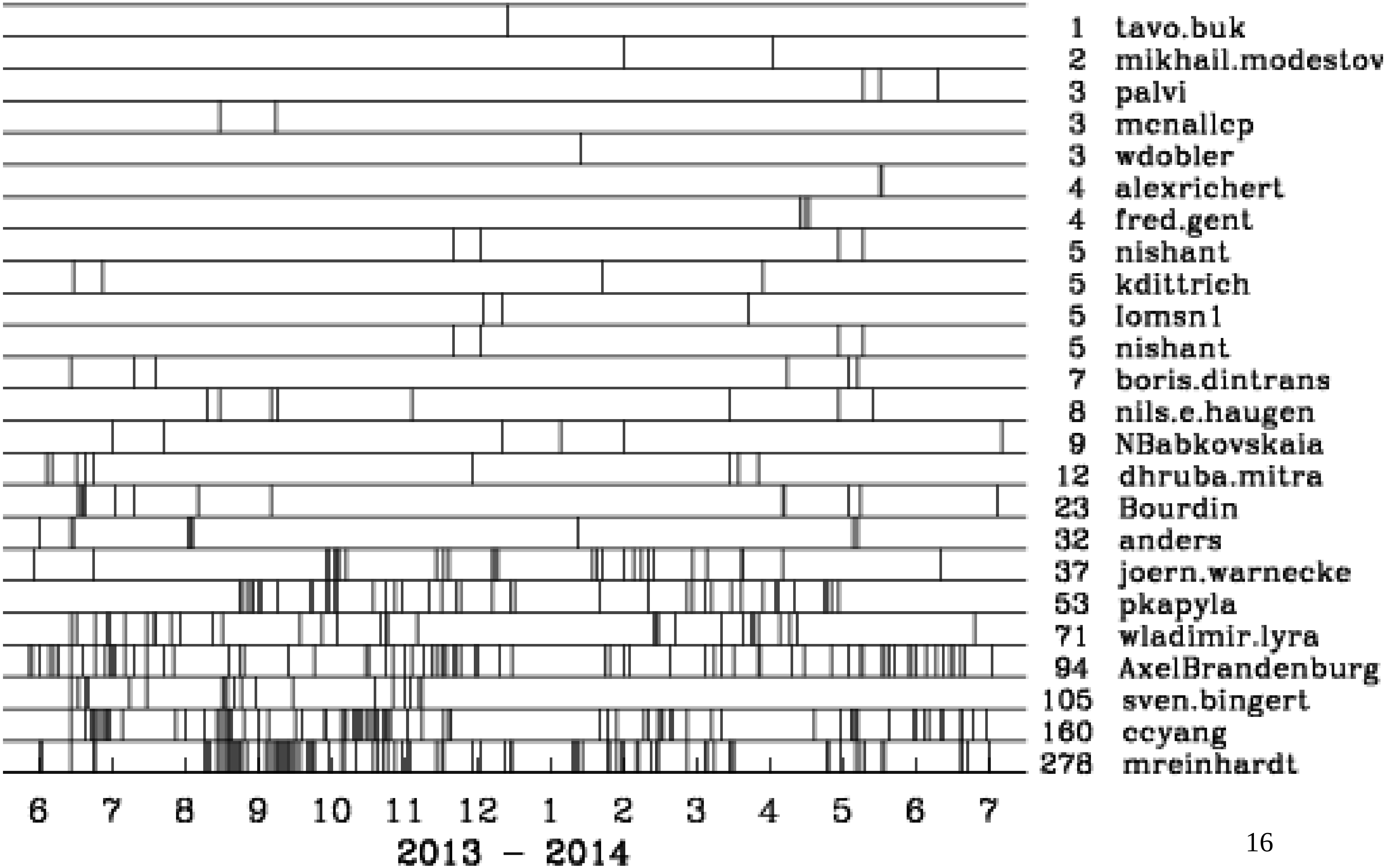
Validation check-ins

Checkout Browse **Changes** Request code review

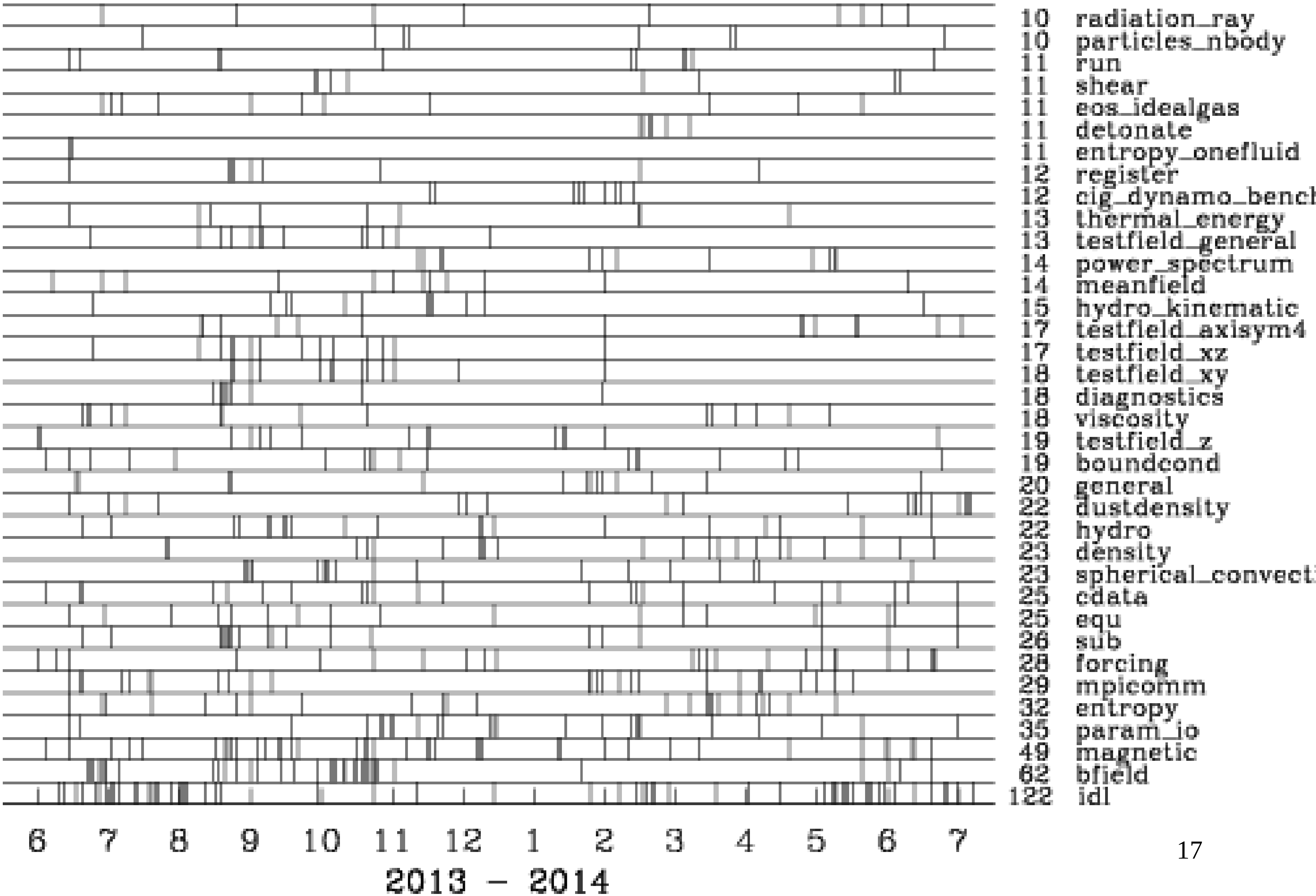
Committed Changes 20483 - 20459 of 20483 Old

	Rev	Scores	Commit log message	Date	Author
★	r20483		automatic validation completed: auto-test on norlx51 by	Today (117 minutes ago)	AxelBrandenburg
☆	r20482		Still not perfect, but produces what is espected: a freely oriented 2D slice from a	Today (12 hours ago)	Bourdin.KIS
★	r20481		added Michiel Lambrechts michiel.lambrechts/gmail.com , , +46 73 613 71 11 Pl	Yesterday (21 hours ago)	AxelBrandenburg
★	r20480		automatic validation completed: auto-test on norlx51 by	Yesterday (26 hours ago)	AxelBrandenburg
☆	r20479		Added a slicer GUI tool to get any possible 2D cut of the 3D data cube. Known iss	Yesterday (35 hours ago)	Bourdin.KIS
★	r20478		automatic validation completed: auto-test on norlx51 by	Jun 15 (2 days ago)	AxelBrandenburg
☆	r20477		Reduced computation to the very minimu, added some comments.	Jun 14 (2 days ago)	Bourdin.KIS
☆	r20476		Change the hostname of my desktop.	Jun 14 (2 days ago)	ccyang@astro.lu.se
★	r20475		automatic validation completed: auto-test on norlx51 by	Jun 14 (3 days ago)	AxelBrandenburg
★	r20474		option of symmetry of forcing function about z direction	Jun 13 (3 days ago)	AxelBrandenburg
★	r20473		commented out !lNEMPI_correction=T !(is now the default)	Jun 11 (6 days ago)	AxelBrandenburg
★	r20472		changed now the default to lNEMPI_correction=.true.	Jun 11 (6 days ago)	AxelBrandenburg
★	r20471		automatic validation completed: auto-test on norlx51 by	Jun 10 (6 days ago)	AxelBrandenburg
☆	r20470		added the README file.	Jun 10 (6 days ago)	dhruba.mitra
☆	r20469		Adding a sample that used particles_potential sample.	Jun 10 (6 days ago)	dhruba.mitra
☆	r20468		inserted logical variable linsert_particles_continiously	Jun 10 (6 days ago)	dhruba.mitra
☆	r20467		New sample ChargedPaerticle_in_MHDturb.	Jun 10 (6 days ago)	dhruba.mitra

Check-ins since last meeting



… same, by module



bfield.f90

```
------------------------------------------------------------------------
r20705 | ccyang@astro.lu.se | 2013-06-26 15:55:02 +0200 (Wed, 26 Jun 2013) | 3 lines

Prototype for directly evolving the magnetic field.

------------------------------------------------------------------------
r20781 | ccyang@astro.lu.se | 2013-07-09 18:04:02 +0200 (Tue, 09 Jul 2013) | 3 lines

Add mesh hyper-resistivity, unfortunately a divergence generator.  This is to be worked on later.


! MVAR CONTRIBUTION 3
```

```
!
      if (lroot) call svn_id("$Id: bfield.f90 21886 2014-06-18 11:03:12Z ccyang@astro.lu.se $")
!
!  Request variable for the magnetic field.
!
      call farray_register_pde('bb', ibb, vector=3, ierr=istat)
      if (istat /= 0) call fatal_error('register_magnetic', 'cannot register the variable bb. ')
      ibx = ibb
      iby = ibx + 1
      ibz = iby + 1
!
!  Request auxiliary variable for the effective electric field.
!
      call farray_register_auxiliary('ee', iee, vector=3, communicated=.true., ierr=istat)
      if (istat /= 0) call fatal_error('register_magnetic', 'cannot register the variable ee. ')
      ieex = iee
      ieey = ieex + 1
      ieez = ieey + 1
!
!  Request auxiliary variable for the current density.
!
      call farray_register_auxiliary('jj', ijj, vector=3, communicated=.true., ierr=istat)
      if (istat /= 0) call fatal_error('register_magnetic', 'cannot register the variable jj. ')
      ijx = ijj
      ijy = ijx + 1
      ijz = ijy + 1
!
    endsubroutine register_magnetic
!***********************************************************************
```

192,1   13%

```
------------------------------------------------------------------------
r21473 | mikhail.modestov | 2014-01-30 14:15:25 +0100 (Thu, 30 Jan 2014) | 1 line

corrected battery term and inserted new initial condition under hydro
------------------------------------------------------------------------
r21238 | AxelBrandenburg | 2013-10-27 21:34:40 +0100 (Sun, 27 Oct 2013) | 5 lines

Fixed a wrong minus sign that I must have introduced (& checked in) during testing in:

  call beltrami(amplaa(j),f,iaa,KY=-ky_aa(j),phase=phasey_aa(j))
------------------------------------------------------------------------
r21039 | mreinhardt@nordita.org | 2013-09-08 01:49:50 +0200 (Sun, 08 Sep 2013) | 3 lines

MR: introduced vector lresi_dep for all possible eta profiles
------------------------------------------------------------------------
r20462 | dhruba.mitra | 2013-06-08 09:27:26 +0200 (Sat, 08 Jun 2013) | 23 lines

Changes to solve for charged particles in an MHD dynamo. The particles do not have drag.
For them we solve the equations,
dv/dt = q/m(E + vXB), where
the electric field, E = -dA/dt and B is the magnetic field.
A sample in the samples directory: ChargedParticle_in_MHDturb
is going to be checked in after this check in.
However, all these works now only for periodic boundary condition on E and B
which are stored as auxiliary variables.
boundcond: added subroutine set_periodic_boundary_on_aux
particles_dust : dummy routine periodic_boundary_on_aux
particles.h : public entry of the same
cdata : iEE to iEEz for electric field
magnetic : MAJOR CHANGES : added a 1-d array (same size and pencils) called dAdt
          which stores all the changes to df(.,.,.,iax:iaz). Before the mean-field
          contributios are added this array is then added to df(... ) and also
          (with negative sign) stored into auxiliary array f(.,.,.,iEEx:iEEz) (if asked)
particles_cdata: additional variables for interpolation of E and B
particles_tracer : dummy routine periodic_boundary_on_aux
```

magnetic.log

param_io.log

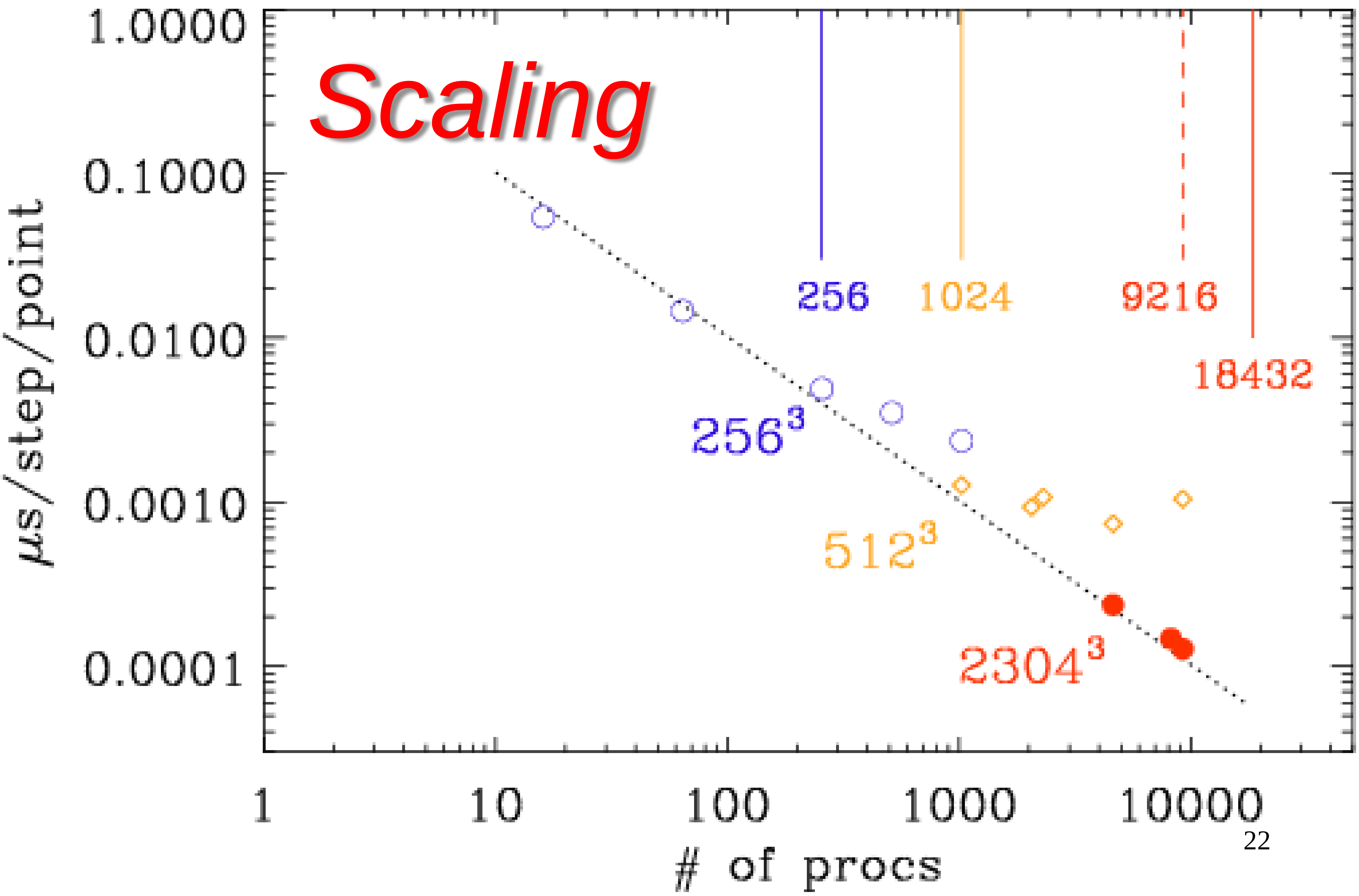
```
param_io.f90, cdata.f90, grid.f90: added pipecoords (pipe coordinate)
equ.f90: now call get_grid_mn for all non-Cartesian coordinates
sub.f90: added pipe coordinates (at least for 1-D) in div operator

------------------------------------------------------------------------
r21497 | mreinhardt@nordita.org | 2014-02-11 17:06:40 +0100 (Tue, 11 Feb 2014) | 2 lines

MR: preparations for downsampled output

------------------------------------------------------------------------
r20551 | sven.bingert | 2013-06-18 17:09:54 +0200 (Tue, 18 Jun 2013) | 1 line

changed from use entropy to use energy
```

mpicomm.log

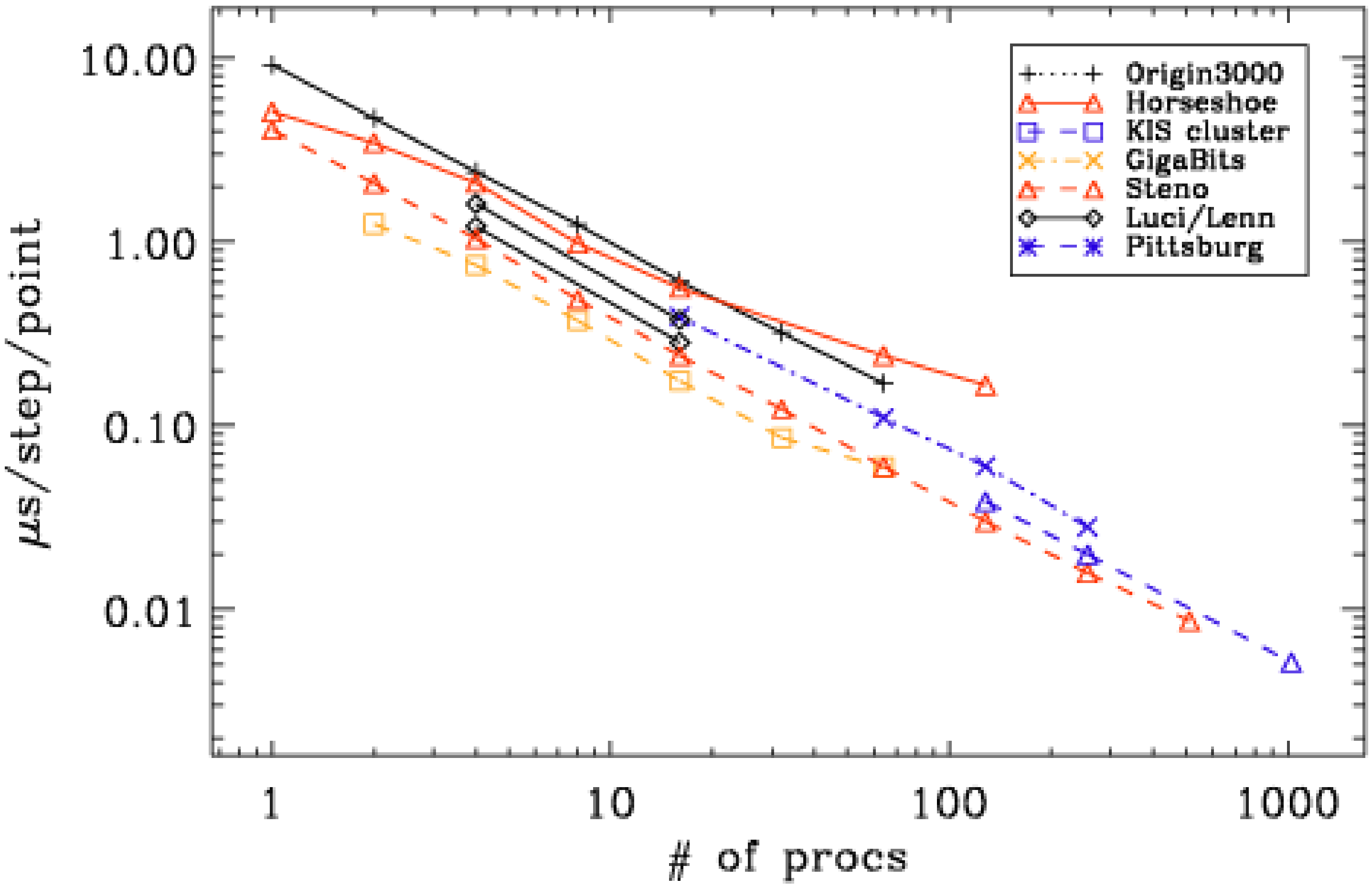
```
------------------------------------------------------------------------
r21796 | alexrichert | 2014-05-15 04:24:16 +0200 (Thu, 15 May 2014) | 2 lines

Added general-purpose MPI_SEND_RECV subroutines for real scalars and arrays of dim 1-4 (used in experim
ental/barneshut.f90).

------------------------------------------------------------------------
r21662 | Bourdin.KIS | 2014-04-06 15:34:56 +0200 (Sun, 06 Apr 2014) | 2 lines

Found a way to circumvent the missing F95 functionality to write one binary buffer as a block to an unf
ormatted file. This should allow Cray compilers to use 'true_parallel_open' reliably.

------------------------------------------------------------------------
r21467 | mreinhardt@nordita.org | 2014-01-29 19:39:47 +0100 (Wed, 29 Jan 2014) | 2 lines

MR: changed calls to write_by_ranges_2d_*
```

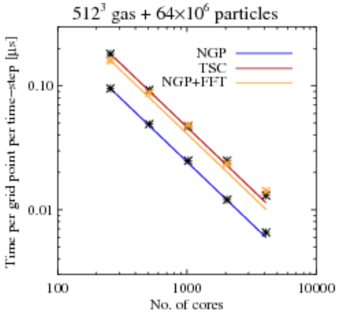
spherical_convection.log

```
r21013 | pkapyla | 2013-09-02 22:31:43 +0200 (Mon, 02 Sep 2013) | 4 lines

First iteration of initial condition for spherical convection (previously
initialized by running an IDL script and generating the stratification).
Currently unsafe for nprocx/=1.

------------------------------------------------------------------------
r21155 | joern.warnecke@gmail.com | 2013-10-08 23:45:54 +0200 (Tue, 08 Oct 2013) | 2 lines

use a different profile for the hcond in the coronal layer

------------------------------------------------------------------------
r21237 | pkapyla | 2013-10-27 20:56:43 +0100 (Sun, 27 Oct 2013) | 4 lines

Corrected computation of physical temperatures at the bottom and top of
the convection zone and in the corona, assuming solar temperature at the
base of the convection zone.

------------------------------------------------------------------------
r21652 | joern.warnecke | 2014-04-05 01:19:43 +0200 (Sat, 05 Apr 2014) | 3 lines

add adaptation for computing the total using a corona.
add small correction to the corona related part
```


Scaling
1.0000
0.1000
0.0100
0.0010
0.0001
μs/step/point
256
1024
9216
18432
256³
512³
2304³
1
10
100
1000
10000
# of procs

Faster and bigger machines





In numbers

- Current validated: 21,940 (quick-start.tex)
  - At last meeting: 20,483
  - At previous meeting: 18,992
- Lines in src/*.f90 currently 245,994 (8.0MB)
  - At last meeting 238,340 (7.9 MB) 355,499 w/ src/*
  - At previous meeting 225,961 (7.8 MB)
- Number of auto-tests? Currently 62
  - w/README files from 43 → 48 → 49 (in 3-D)
  - and from 20 → 22 → 25 (in 2-D)

pencil-code

GENERAL
Summary
Journal Entries
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DEVELOPMENT
Code Analysis
Contributors
Commits
Enlistments

EDIT
Permissions
History

The Pencil Code is primarily designed to deal with weakly compressible turbulent flows, which is why we use high-order first and second derivatives. To achieve good parallelization, we use explicit (as opposed to compact) finite differences. Typical scientific targets include driven MHD turbulence in a periodic box, convection in a slab with non-periodic upper and lower boundaries, a convective star embedded in a fully nonperiodic box, accretion disc turbulence in the shearing sheet approximation, self-gravity, non-local radiation transfer, dust particle evolution with feedback on the gas, etc. A range of artificial viscosity and diffusion schemes can be invoked to deal with supersonic flows. For direct simulations regular viscosity and diffusion is being used.

The code is written in well-commented Fortran90.

For a more detailed description and a full introduction see the manual.pdf file (see under links on the right).

Remember to sign up for the Pencil Code User Meeting (see link on the right)!

Where's the download?

Homepage
http://code.google.com/p/pencil-code

Licensed under
GNU General Public License 3 or later

Tagged as
flow | fortran90 | flowanalysis | gpl | mpi | turbulent | mhd | edit tags

Who uses pencil-code?

7 users
I USE THIS

Who contributes to pencil-code?

See All Contributors

Olhoh.net analysis

Journal Entries

0 followers FOLLOW

TIMELINE VIEW

No entries yet. Link your entries with 'pencil-code' to include this project.

Ohloh Analysis Summary

- Mostly written in Fortran (Fixed-format)
- Mature, well-established codebase
- Very large, active development team
- Very few source code comments

View All Possible Factoids

Updated 06 Apr 2011 05:43 UTC

Ratings & Reviews

Community Rating
5.0/5.0
Based on 2 user ratings.

Your Rating
Click to rate this project.

Be the first to review this project!

Links

0 links submitted so far. Submit your own links.

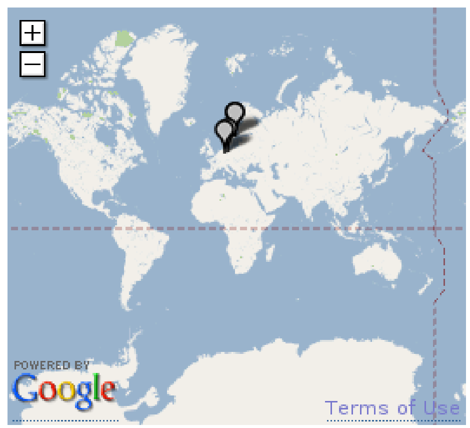
News

Who manages pencil-code?

I'm a manager

Where in the world?

Users Contributors View Larger Map



Showing 4 of 7 users.

Related Projects by Tags

Cecil.FlowAnalysis, imhd-mobile, mplabs, PPIV, wingcfd

Related Projects by Tags

Cecil.FlowAnalysis, imhd-mobile, mplabs, PPIV, wingcfd

Project Cost

This calculator estimates how much it would cost to hire a team to write this project from scratch. More »

Include	Markup And Code
Codebase	402,279
Effort (est.)	108 Person Years
Avg. Salary	$ 55000 year
	$ 5,931,082

Widgets

Learn how to embed this and other widgets on your site.

pencil-code

File Edit View History Bookmarks Tools Help

http://www.nordita.org/~brandenb/teach/PencilCode/ Floatopia

Pencil Journals Meetings Other sök Translate Axel AstroDyn Solar physics Prog

People - pencil-code - A high... Numerical Experiments

Numerical Experiments

Numerical Experiments, School on Astrophysical Turbulence and Dynamos, ICTP Trieste, 20-30 April 2009, by Axel Brandenburg & Boris Dintrans

→ Working link, stable link (less frequently updated)

- Schedule for Trieste, April 2009
- Solar Physics and MHD course (Stockholm, May 2009)
- Evry Schatzman school'09 in Aussois, September 2009 (PowerPoint Presentation)

Pencil Code home page, Manual, PowerPoint Presentation, http://pencil-code.googlecode.com/

Python with the Pencil Code

Additional reading:

Brandenburg, A.: 2003, ``Computational aspects of astrophysical MHD and turbulence,'' in *Advances in nonlinear dynamos (The Fluid Mechanics of Astrophysics and Geophysics, Vol. 9)*, ed. A. Ferriz-Mas & M. Núñez, Taylor & Francis, London and New York, pp. 269-344 *(astro-ph/0109497, ADS, PDF)*

Brandenburg, A., & Subramanian, K.: 2005, ``Astrophysical magnetic fields and nonlinear dynamo theory,'' *Phys. Rep.* **417**, 1-209 *(astro-ph/0405052, ADS, PDF)*

Brandenburg, A.: 2007, ``The solar interior - radial structure, rotation, solar activity cycle,'' in *Handbook of Solar-Terrestrial Environment*, ed. Y. Kamide & A. C.-L. Chian, Springer, pp. 27-54 *(astro-ph/0703711)*

Notes on Solar Physics and Magnetohydrodynamics [pdf] (over 100 pages, most of which is not covered in the course)

Links:

Astrophysical Dynamos (ERC project page)

Homepages of Axel Brandenburg and Boris Dintrans

$Date: 2010-09-15 08:20:56 $, $Author: brandenb $, $Revision: 122 $

Numerical Exper... pencil-code@nl6... [xterm] xterm xterm xterm

Tutorial pages

http://www.nordita.org/~brandenb/teach/PencilCode/schedule.html

Numerical Experiments: Schedule

- Mon 20 Apr: *Setting up your account and downloading the Pencil Code*

  Setting up the Pencil Code

- Tue 21 Apr: *High order numerical schemes and Pencil Code*

  Effective wavenumbers, exercise [pdf, 1 page]
  Advection tests, exercise [pdf, 1 page]

- Wed 22 Apr: *Nonlinear sound waves and Burgers shock*

  Nonlinear sound waves
  Nonlinear Alfven waves
  Burgers shock

- Mon 27 Apr: *Brunt-Väisälä oscillations*

  Brunt-Väisälä oscillations

- Tue 28 Apr: *Helical dynamos*

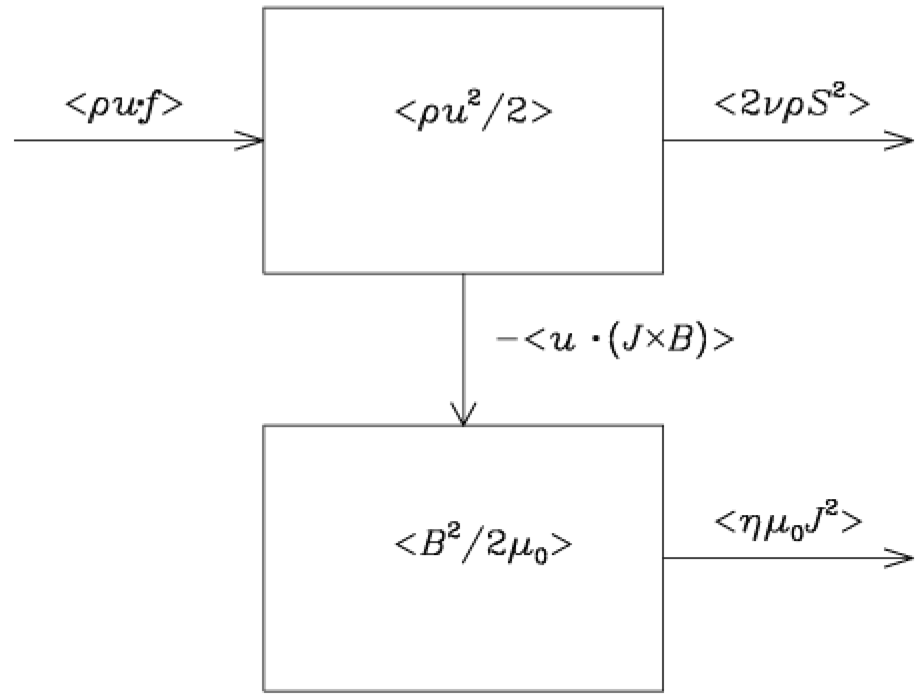
  Helical dynamos, exercise [pdf, 1 page]

- Wed 29 Apr: *Setting up new experiments*

  MixedTopics

Numerical Experiments homepage

Energetics

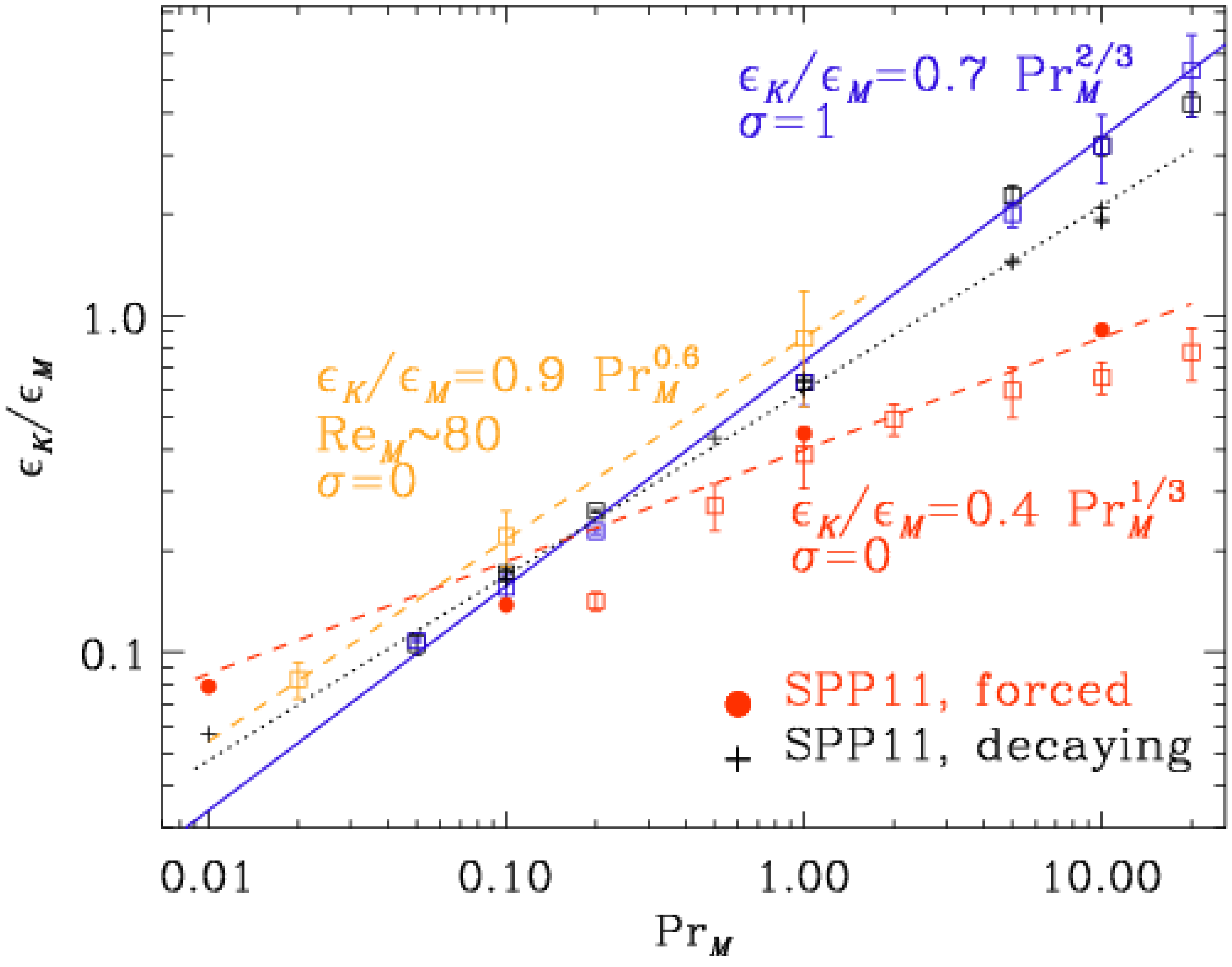


dynamo term equal
to dissipation term

$$\frac{\mathrm{d}}{\mathrm{d}t}\langle\rho\boldsymbol{u}^2/2\rangle = \langle p\boldsymbol{\nabla}\cdot\boldsymbol{u}\rangle + \langle\boldsymbol{u}\cdot(\boldsymbol{J}\times\boldsymbol{B})\rangle + \langle\rho\boldsymbol{u}\cdot\boldsymbol{f}\rangle - \langle 2\rho\nu\mathbf{S}^2\rangle, \tag{6}$$

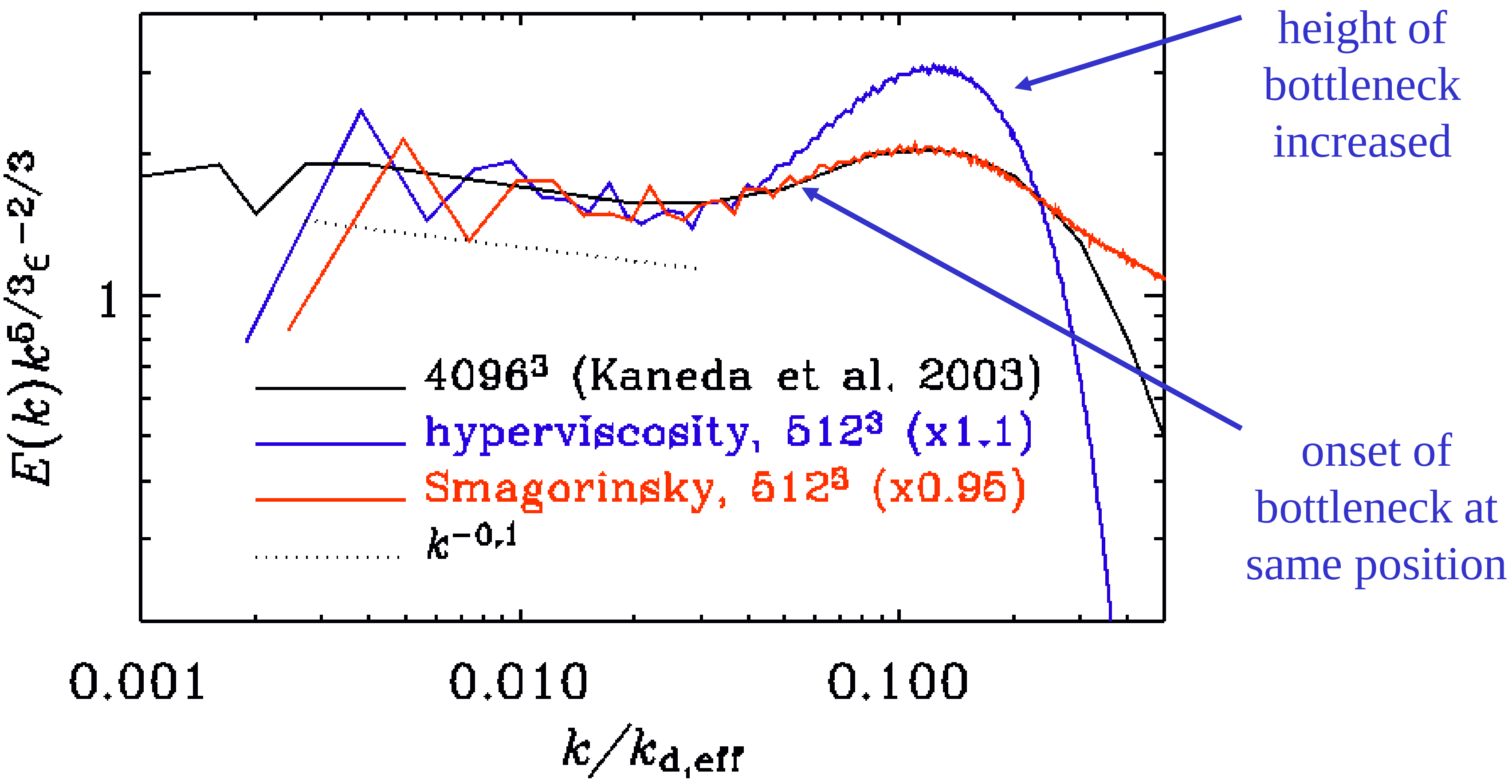
$$\frac{\mathrm{d}}{\mathrm{d}t}\langle\boldsymbol{B}^2/2\mu_0\rangle = -\langle\boldsymbol{u}\cdot(\boldsymbol{J}\times\boldsymbol{B})\rangle - \langle\eta\mu_0\boldsymbol{J}^2\rangle, \tag{7}$$

Pr_M dependence of conversion



Brandenburg (2014, ApJ, in press)

Hyperviscous, Smagorinsky, normal



Inertial range unaffected by artificial diffusion

Haugen & Brandenburg (PRE, astro-ph/0402301)

Goals/questions for 2015

and goals for this week

- Go through UserMeetings/2014/agenda.txt
- Is there still a need for a paper?
- Is there a good way to trace papers using pc
- Editing webpage
- Photos?

Photos

26-30 Jul, 2010: 6th meeting [notes] in New York, American Museum of National History (USA).
24-28 Aug, 2009: 5th meeting [notes] in Heidelberg, Max Planck Institute for Astronomy (Germany).
19-22 Aug, 2008: 4th meeting [notes] in Leiden, Leiden Observatory (Netherlands).
14-17 Aug, 2007: 3rd meeting [notes] in Stockholm, Nordita (Sweden).
13-15 Jul, 2006: 2nd meeting [videos] in Copenhagen, Nordita (Denmark).
26-28 Jun, 2005: 1st meeting in Copenhagen, Nordita (Denmark).

Photos

Meetings

07-11 Jul, 2014: **10th meeting** **[notes]** in Göttingen, Max Planck Institute for Solar System Research (Germany).

17-20 Jun, 2013: **9th meeting** **[notes]** in Lund, Lund Observatory (Sweden).

18-21 Jun, 2012: **8th meeting** **[notes]** in Helsinki, Physics Department (Finland).

24-28 Oct, 2011: **7th meeting** **[notes]** in Toulouse, Observatoire Midi-Pyrénées (France).

26-30 Jul, 2010: **6th meeting** **[notes]** in New York, American Museum of National History (USA).

Vector potential (in view of new B-module)

- **B**=curl**A**, advantage: div**B**=0
- **J**=curl**B**=curl(curl**A**) =curl2**A**
- Not a disadvantage: consider Alfven waves

B-formulation

$$\frac{\partial u}{\partial t} = B_0 \frac{\partial b}{\partial z}, \quad \text{and} \quad \frac{\partial b}{\partial t} = B_0 \frac{\partial u}{\partial z}$$

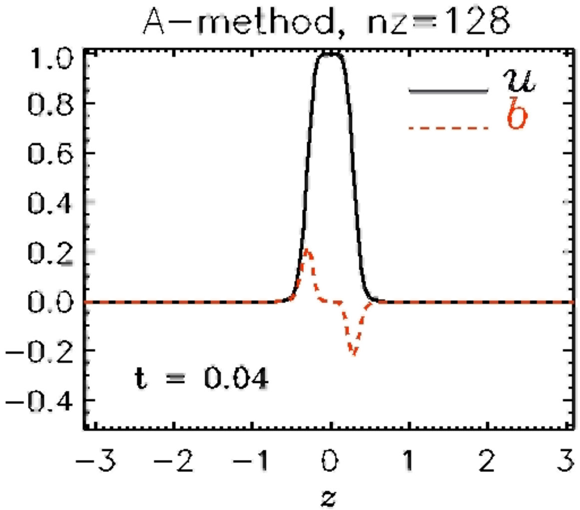
A-formulation

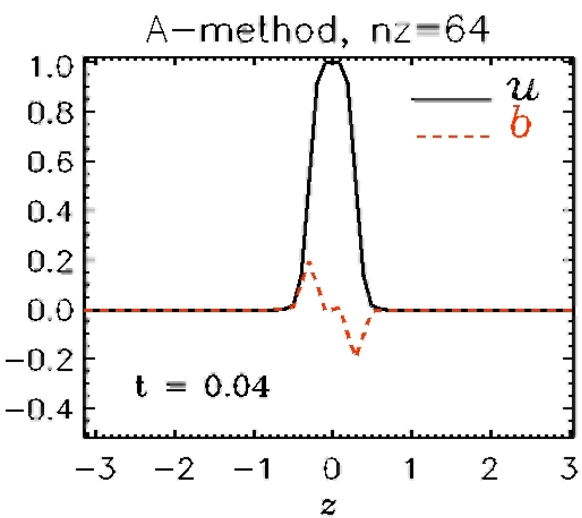
$$\frac{\partial u}{\partial t} = B_0 \frac{\partial^2 a}{\partial z^2}, \quad \text{and} \quad \frac{\partial a}{\partial t} = B_0 u$$

2^{nd} der once is better than 1^{st} der twice!

Comparison of A and B methods

$$\frac{\partial u}{\partial t} = B_0 \frac{\partial^2 a}{\partial z^2} + \upsilon \frac{\partial^2 u}{\partial z^2}, \quad \text{and} \quad \frac{\partial a}{\partial t} = B_0 u + \eta \frac{\partial^2 a}{\partial z^2}$$





$$\frac{\partial u}{\partial t} = B_0 \frac{\partial b}{\partial z} + \upsilon \frac{\partial^2 u}{\partial z^2}, \quad \text{and} \quad \frac{\partial b}{\partial t} = B_0 \frac{\partial u}{\partial z} + \eta \frac{\partial^2 b}{\partial z^2}$$