# P464 Computational Project — Research Questions

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Equations are solved for the kinematic regime unless specified otherwise, with diffusivity $\eta_\mathrm{T} = \eta + \eta_\mathrm{t}$ taken to be constant in time and space. The basic properties of the solution are the exponential growth rate (eigenvalue) $\gamma$ (local growth rate if solving in $z$) or $\Gamma$ (global growth rate if solving in $r$), pitch angle $p_B(z)$ or $p_B(r)$ and critical dynamo number $D_\mathrm{c}$, as well as the spatial dependence of the solution (eigenfunction) $B_r(z)$, $B_\phi(z)$ or $B_r(r)$, $B_\phi(r)$. Use parameter values appropriate for galaxies like the Milky Way. Unless otherwise specified, you may neglect the $\alpha^2$ effect and set $\overline{V}_r$ and $\overline{V}_z$ to zero. For those solving the equations in $r$, choices need to be made about the radial dependence of the parameters. For those solving the equations in $z$ you may take $\alpha \propto \sin(\pi z/h)$ unless specified otherwise.

1. Explore the differences between the $\alpha^2\!-\!\Omega$ dynamo and $\alpha\!-\!\Omega$ dynamo (1D in $z$) — **Abhinav**
2. Explore the effects of including outflows, that is $\overline{V}_z \neq 0$. You may assume that $\overline{V}_z = V_0 z/h$ (1D in $r$) — **Adhil**
3. Explore the differences between the $\alpha^2$ dynamo and the $\alpha\!-\!\Omega$ dynamo (1D in $z$) — **Anand**
4. Explore the effects of outflows (winds or fountain flow) $\overline{V}_z \neq 0$ (1D in $r$) — **Aniket**
5. Explore the sensitivity of the solution to the seed field. E.g. how long does it take the solution to converge to the eigenfunction for a given seed field? (1D in $z$) — **Aritra**
6. Explore the sensitivity of the solution to the seed field. E.g. how long does it take the solution to converge to the eigenfunction for a given seed field? (1D in $r$) — **Diptarko**
7. Test the validity of the no-z approximation (1D in $z$) — **Gaurav**
8. Explore the effects of radial inflow, that is $\overline{V}_r < 0$ (1D in $r$) — **Gayathri K**

9. Make $\overline{V}_z$ increase with time so that it quenches the dynamo (1D in $z$) — **Mohamed**
10. Make $\overline{V}_z$ increase with time so that it quenches the dynamo (1D in $r$) — **Niti**
11. Assume $\alpha(z) = \alpha_0(z)/(1 + B^2/B_{\rm eq}^2)$ and obtain saturated solutions (1D in $z$) — **Ganesh**
12. Assume $\alpha(r) = \alpha_0(r)/(1 + B^2/B_{\rm eq}^2)$ and obtain saturated solutions (1D in $r$) — **Ritabik**
13. Explore the sensitivity of the solutions to the order of the finite differencing algorithm (1D in $z$) — **Sagar**
14. Explore the sensitivity of the solutions to the order of the finite differencing algorithm (1D in $r$) — **Soham**
15. Explore the sensitivity of the solutions to the functional form adopted for $\alpha(z)$, e.g. $\alpha_0 \sin(\pi z/h)$ or $\alpha_0 z/h$ or $\pm\alpha_0$ with or $\alpha(z)$ an even function of $z$ (1D in $z$) — **Sunil**
16. Explore the sensitivity of the solutions to different choices of boundary conditions (including the location of the outer radius) (1D in $r$) — **Swaroop**
17. Explore the sensitivity of the solutions to the order of the Runge-Kutta algorithm (1D in $z$) — **Swosti**
18. Explore the sensitivity of the solutions to the order of the Runge-Kutta algorithm (1D in $r$) — **Upasana**
19. For what values of $R_\alpha$ and $R_\omega$ are the solutions of the $\alpha^2$—$\Omega$ dynamo oscillatory? (1D in $z$) — **Abha**
20. Explore how the solutions evolve when one allows the rotation curve to change with time in a realistic way as the galaxy evolves (1D in $r$) — **Arshia**
21. Solve the equations using vector potential $A$ ($\phi = 0$ gauge is simplest; see Brandenburg 2003, Sec. 5) and compare with the solutions for the equations in $B$ — what are the differences and which method is most efficient? (1D in $z$) — **Chandan**
22. Solve the equations using vector potential $A$ ($\phi = 0$ gauge is simplest; see Brandenburg 2003, Sec. 5) and compare with the solutions for the equations in $B$ — what are the differences and which method is most efficient? (1D in $r$) — **Gayathri S**
23. Test the formula for critical dynamo number from the no-$z$ solution, by varying $\overline{V}_z$ (1D in $z$) — **Krishna**

24. Compare the local growth rate $\gamma(r)$ from the no-$z$ approximation (tutorial 1) with the global growth rate $\Gamma$ (1D in $r$) — **Maitrey**
25. Assume quadrupolar symmetry to set boundary conditions at the midplane and solve the equations using half the grid (e.g. $0$ to $h$ instead of $-h$ to $h$). Compare with the standard method using the full grid. Which method is more efficient, more accurate? (1D in $z$) — **Oommen**
26. Compare the solutions obtained under different, realistic prescriptions for disk flaring (1D in $r$) — **Rajalakshmi**
27. For the $\alpha^2$—$\Omega$ dynamo explore the parameter space $R_\alpha$, $R_\Omega$ (1D in $z$) — **Ratul**
28. How does the solution change if radial derivatives are neglected? Is it faster to solve the equations? (1D in $r$) — **Sanyam**
29. Explore the dependence of the solution on the time step. Determine the maximum time step as a function of the dynamo number and growth rate. How does the choice of time step affect the computational efficiency? (1D in $z$) — **Sumegha**
30. Compare different realistic prescriptions for $\overline{V}_z(r)$ (1D in $r$) — **Vasanth**
31. Explore the dependence of the solution on the spatial resolution. Determine the minimum number of grid points as a function of the dynamo number and growth rate. How does the choice of resolution affect the computational efficiency? (1D in $z$) — **Vishnu**