Resolutions of 180^{o} Ambiguity in the Observed Transverse Magnetic Fields

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Presentation Plan

- What is the 180° ambiguity problem?
- A brief introduction of methods of removal of ambiguity
- Importance of the problem
- Tests of three magnetic field models
- Summary

Reference Field Methods (Method 1)

$B_{reference}$ is commonly calculated for magnetic potential field with observed vertical field in the photosphere as boundary condition

e.g. G. Allen Gary and M.J. Hagyard, (1990), Solar Physics, 126, 21-36

Dissipation of Magnetic Filed Pressure (Method 2)

Assume the magnetic field is force-free:

$$\nabla \times \boldsymbol{B} = \alpha \boldsymbol{B}$$

and

$$\nabla \cdot \boldsymbol{B} = 0.$$

$$\frac{1}{2}\frac{\partial}{\partial z} B^2 = B_x \frac{\partial B_z}{\partial x} + B_y \frac{\partial B_z}{\partial y} - B_z \left(\frac{\partial B_x}{\partial x} + \frac{\partial B_y}{\partial y} \right).$$

Criterion: $$\frac{\partial B^2}{\partial z} \leq 0$$

e.g. S. Cuperman, J. Li and M. Semel, (1993), A&A, 268, 749-764

Magnetic field Divergence-Free (Method 3)

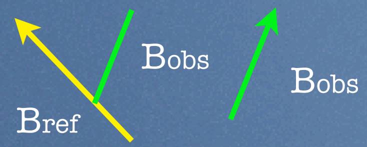
$$\nabla \cdot B \equiv 0$$

$$\frac{\partial B_z}{\partial z}\left(\frac{\partial B_x}{\partial x} + \frac{\partial B_y}{\partial y}\right) = -\left(\frac{\partial B_z}{\partial z}\right)^2$$

$$P \equiv \Delta B_z(\Delta B_x + \Delta B_y) \leq 0$$

e.g. J. Li, s. Cuperman, and M. Semel, (1993), 279, 214-224

Method 1



Method 2

$$\frac{\partial B^2}{\partial z} \leq 0$$

Method 3

$$\boldsymbol{\nabla} \cdot \boldsymbol{B} \equiv \mathbf{0}$$

An analytical force-free magnetic field
Low (1982)

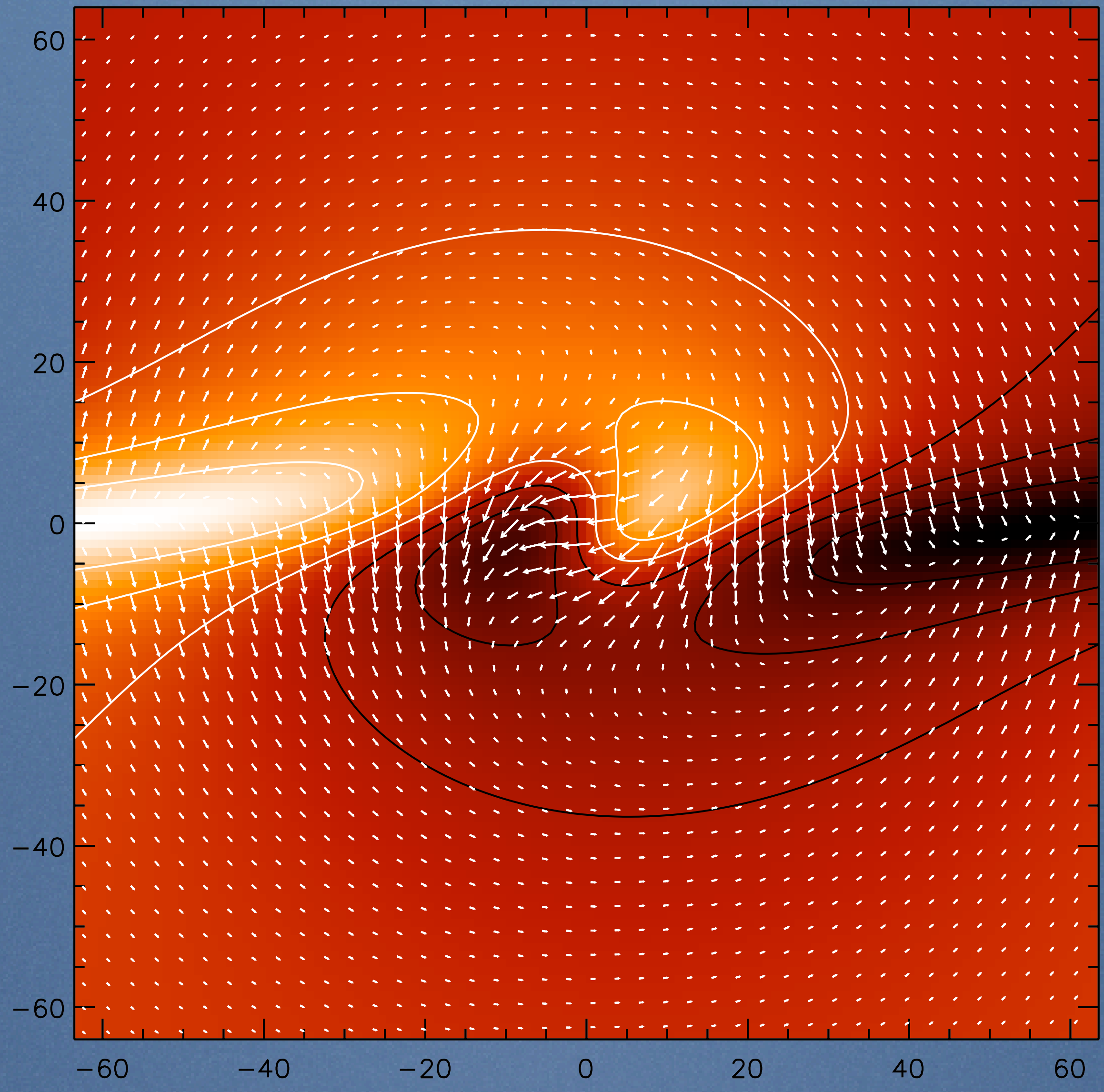
Simulation of a Twisted Flux Tube
Amari and Luciani(1999)

Simulation of 3D coronal magnetic field
Fan (2004)

3 methods apply to 3 MHD models

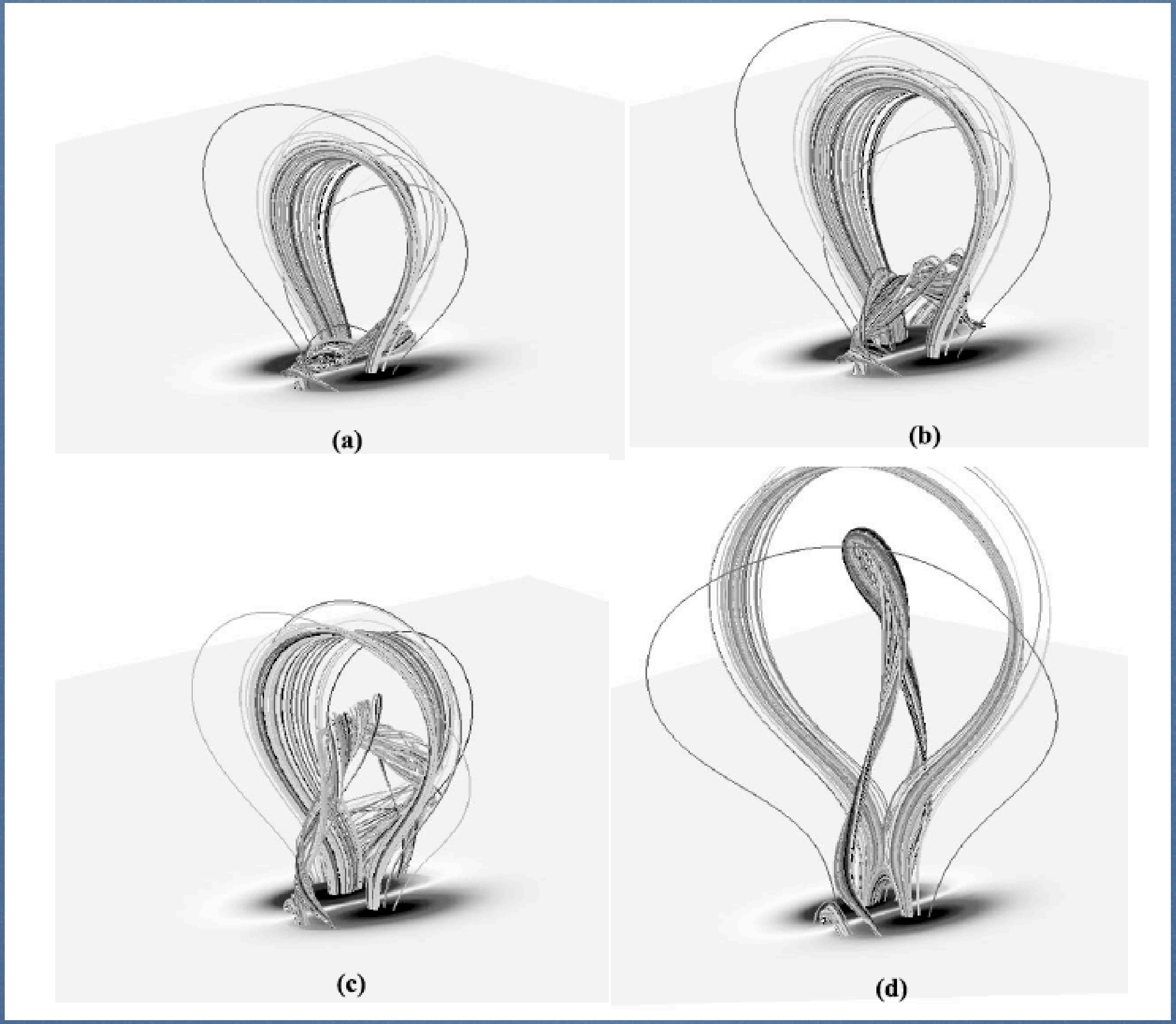
Low's Model

an analytical solution of force-free magnetic field



Amari Model

a model to simulate the flux tube eruption



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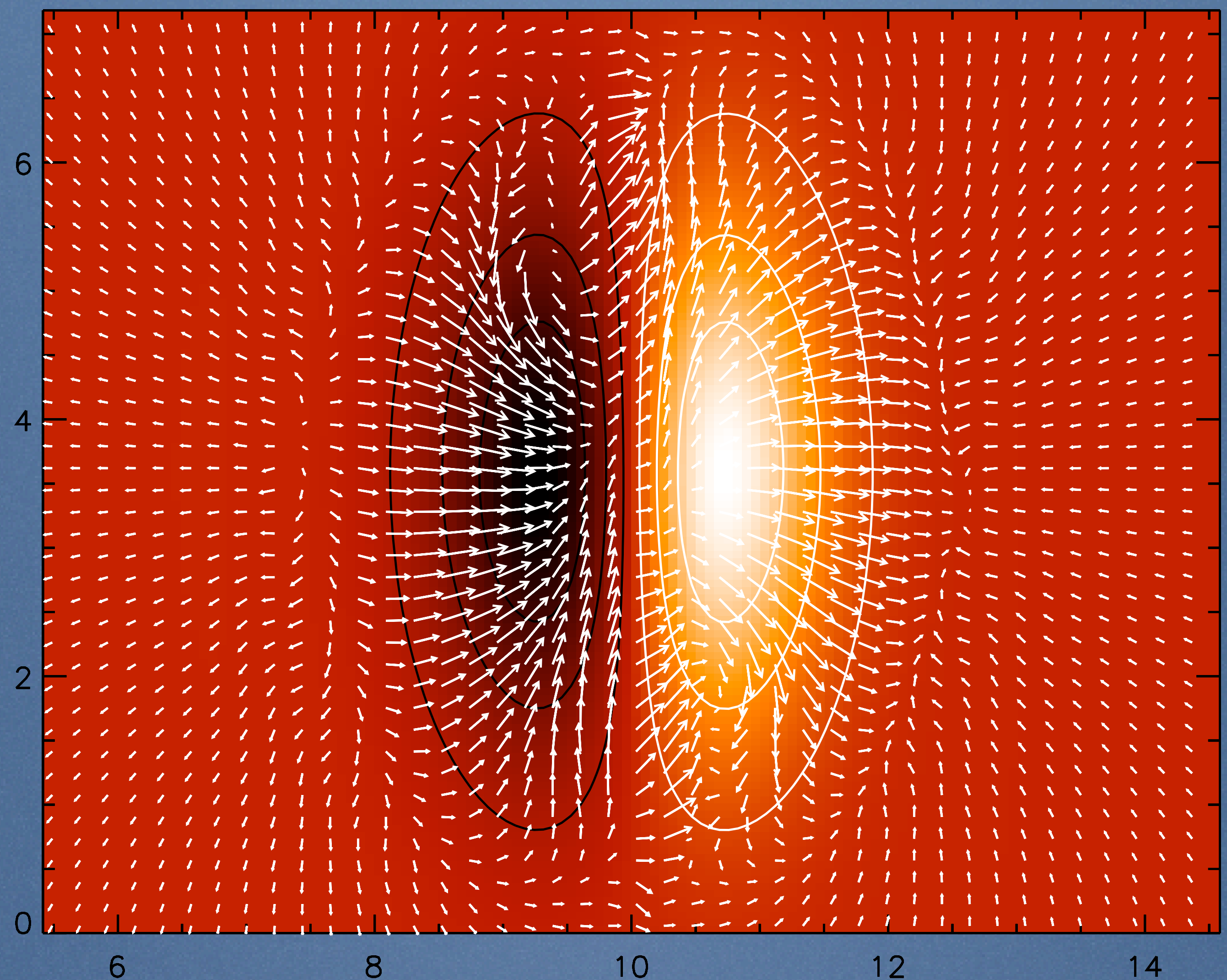
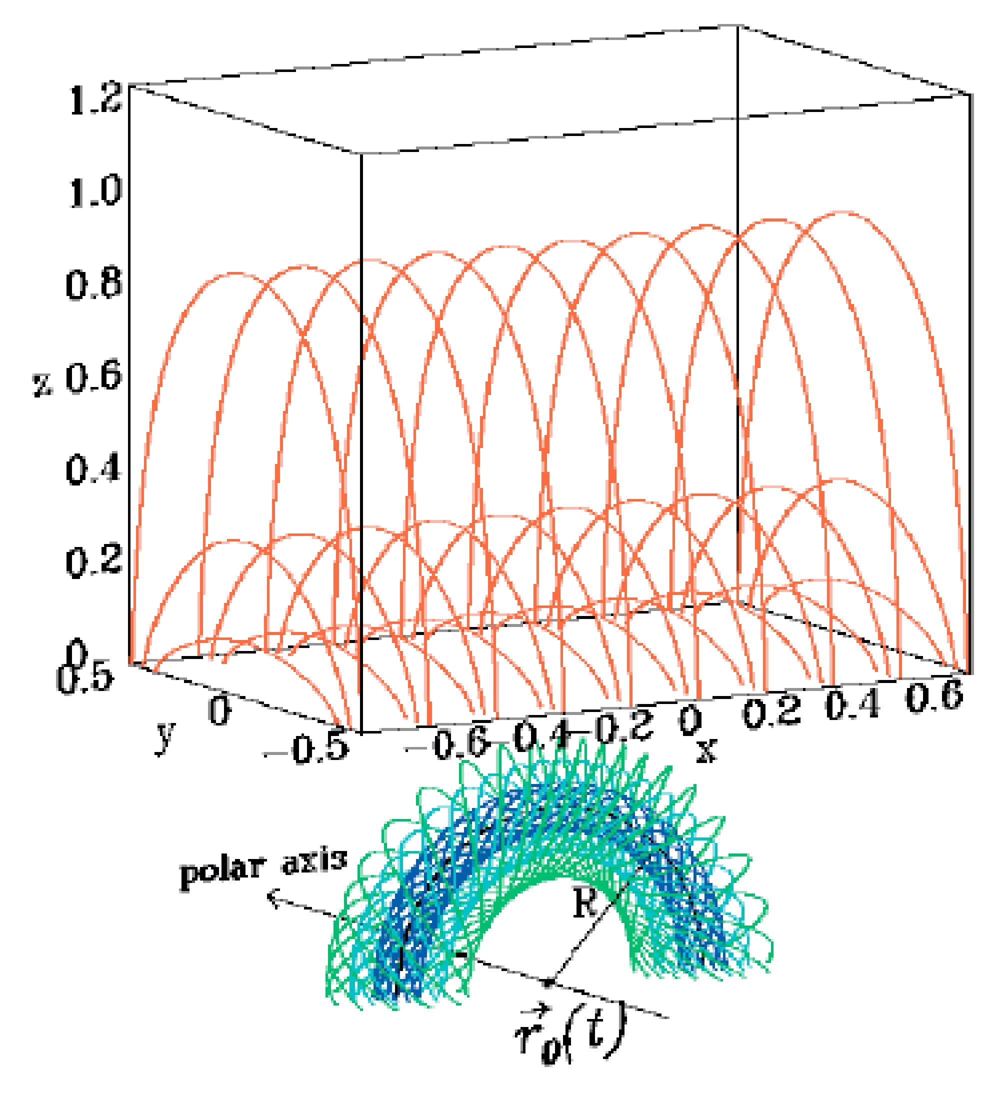


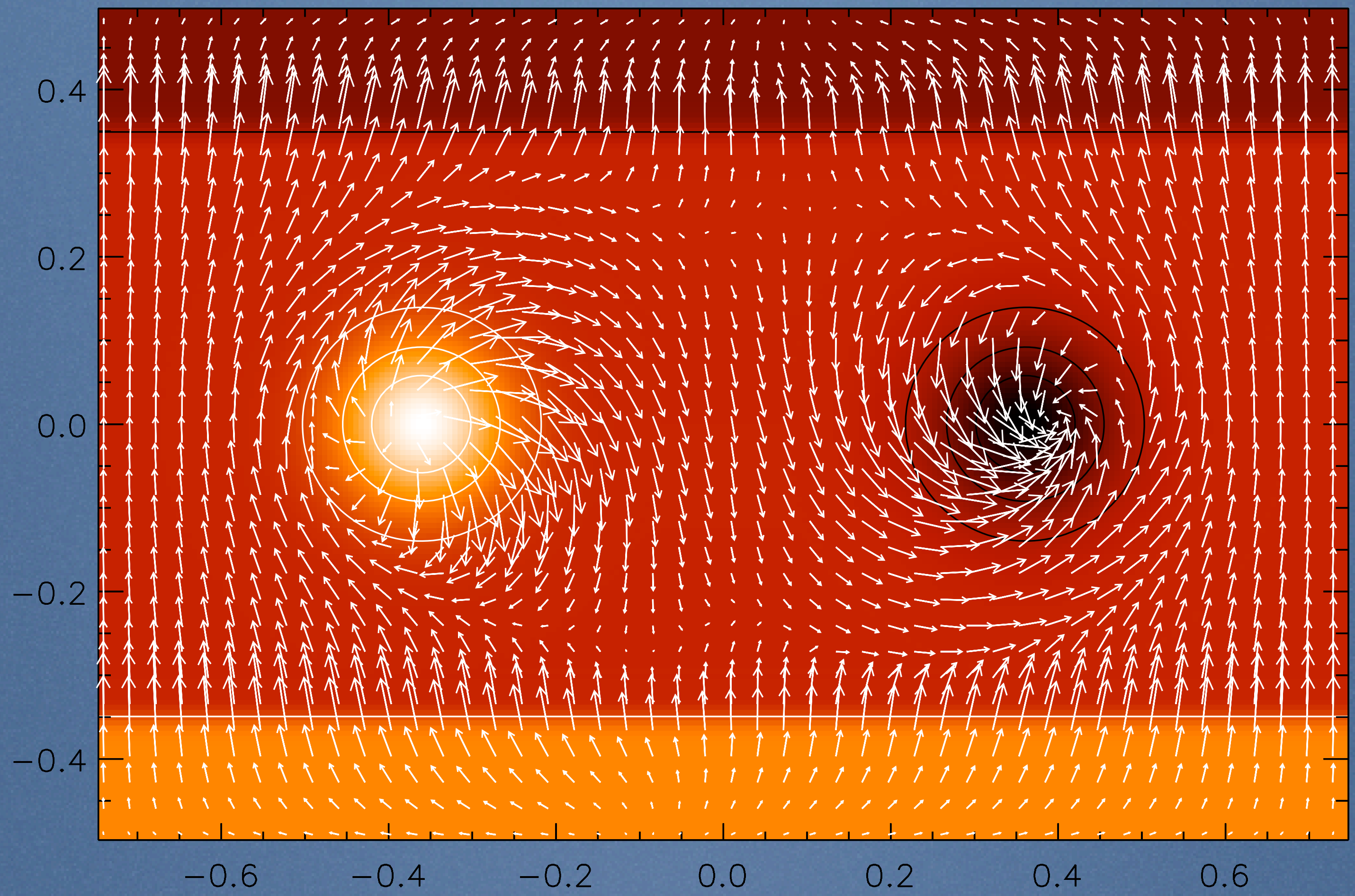
Fan Model

a model to simulate the 3D coronal magnetic field as the result of a twisted flux tube emergence

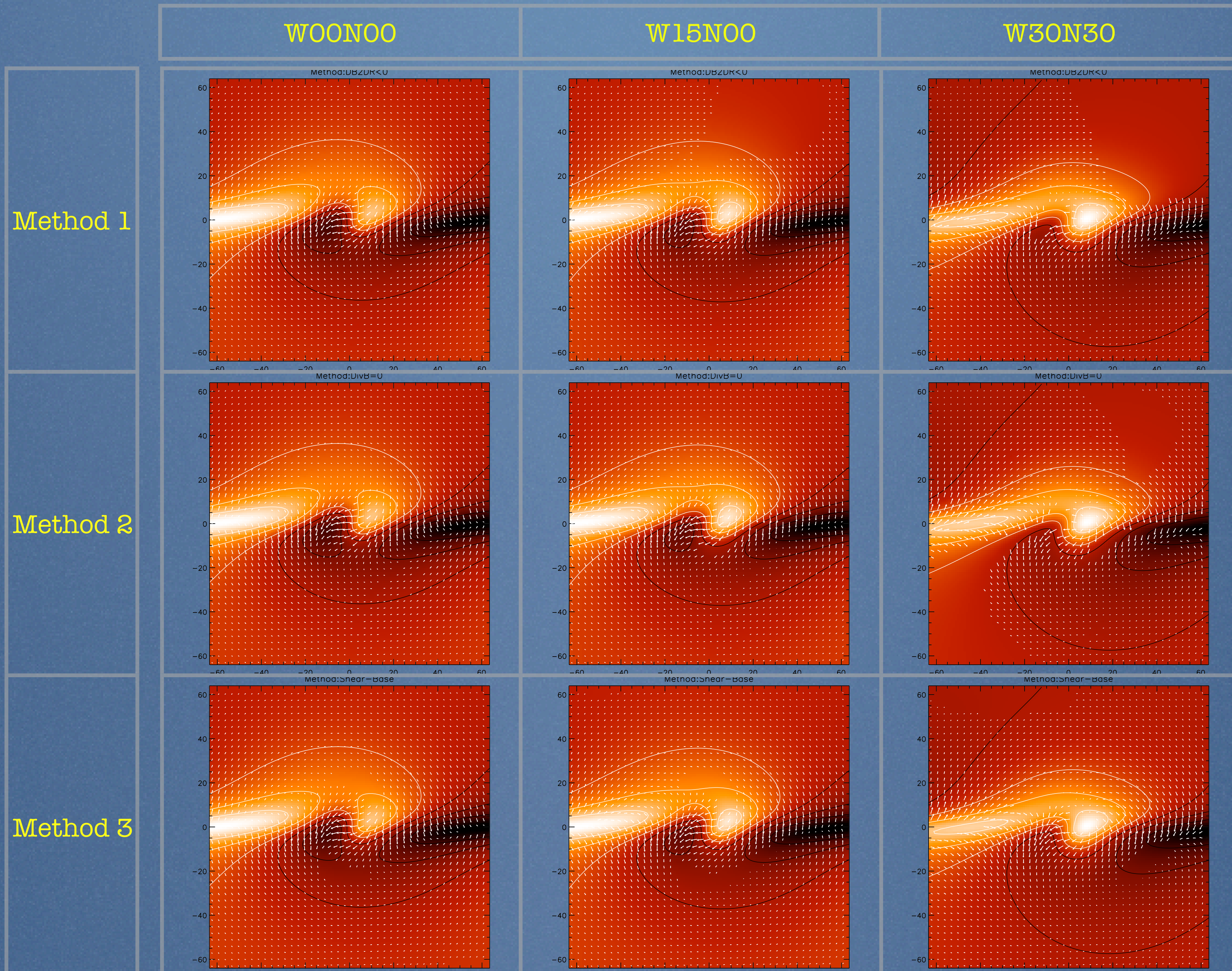


Fan Model

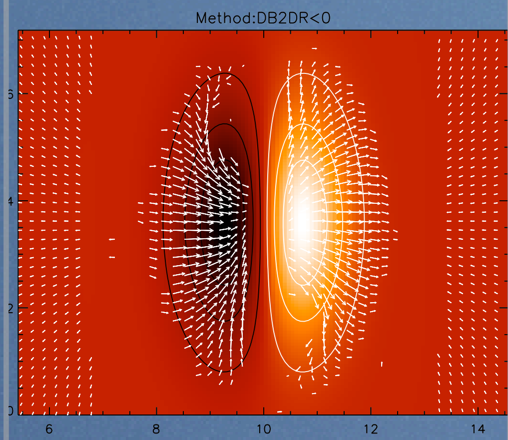
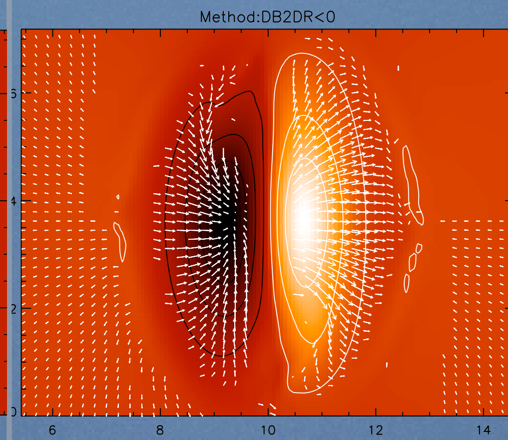
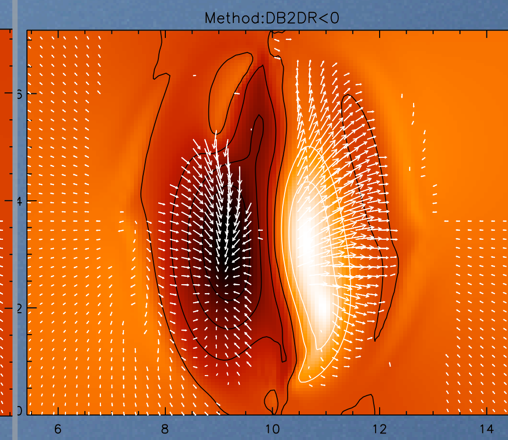
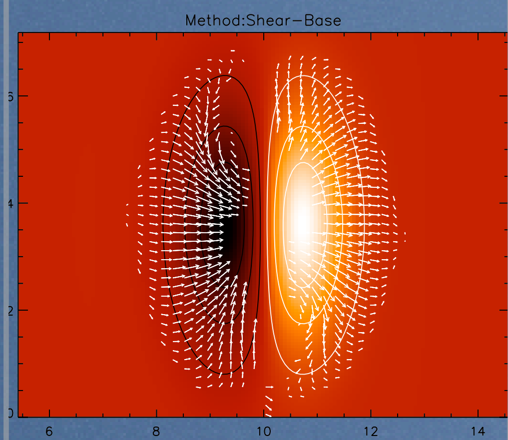
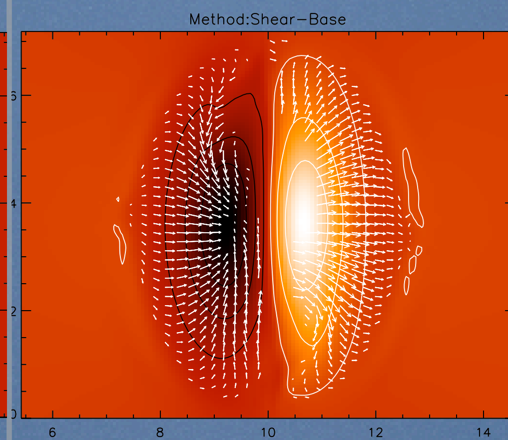
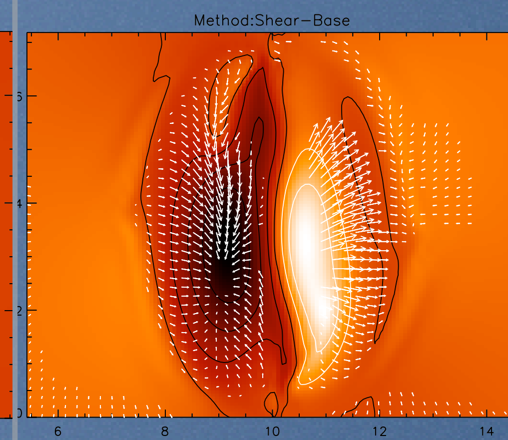
2D Configuration at the base of corona



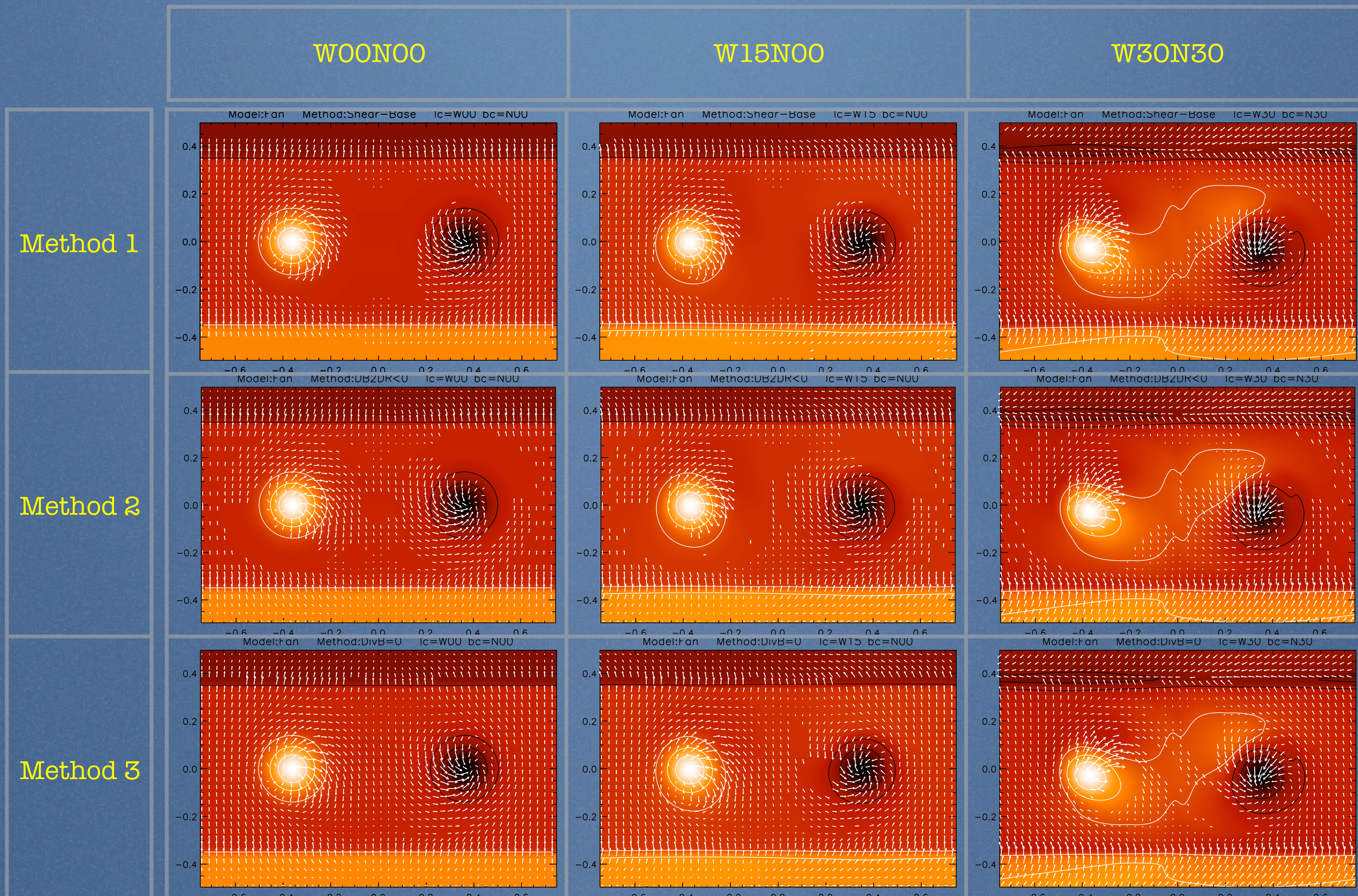
Success with Low Model



Success with Amari Model

	W00N00	W15N00	W30N30
Method 1			
Method 2			

Success with Fan Model



Resolution Method Comparison

percentage of success

Model	Method	w00n00	w15n00	w30n30
Amari	1	54.0	32.4	37.8
	2	56.8	55.7	54.0
	3			
Fan	1	70.3	70.5	78.6
	2	77.4	73.4	72.3
	3	98.2	95.3	88.9
Low	1	96.9	95.3	92.5
	2	99.0	87.9	80.2
	3	98.0	96.9	77.1

Summary

- All three methods work well with a force-free field configuration. However, the photospheric fields are not force-free.
- Encouraging news is that the success rate is significantly high with Divergence-free method for the numerical simulated coronal fields (Fan's model)
- Both methods 1 and 2 failed at the magnetic neutral lines for a twisted flux rope model (Amari's model), but work better for the flux emergence simulation (Fan's model)
- In twisted flux tube, sunspot centers have larger success rate
- Success rate largely depends on the magnetic configuration in the photosphere