

2011. 1. 31

名古屋大学

中緯度短波レーダ研究会

対流パターンと沿磁力線電流の相関構造

田中高史

サブストーム(全ての磁気圏)モデルに必要な4条件

- 電流系がカバランスを満たすこと

$$(\mathbf{J} \times \mathbf{B}) = \left(\rho \frac{d\mathbf{V}}{dt} + \nabla P \right)$$

- J_{\parallel} にシア一流が付随すること

$$\frac{\mathbf{v}}{C_A} = \pm \frac{\mathbf{b}}{B_0}$$

- エネルギー供給 → ダイナモが形成されること

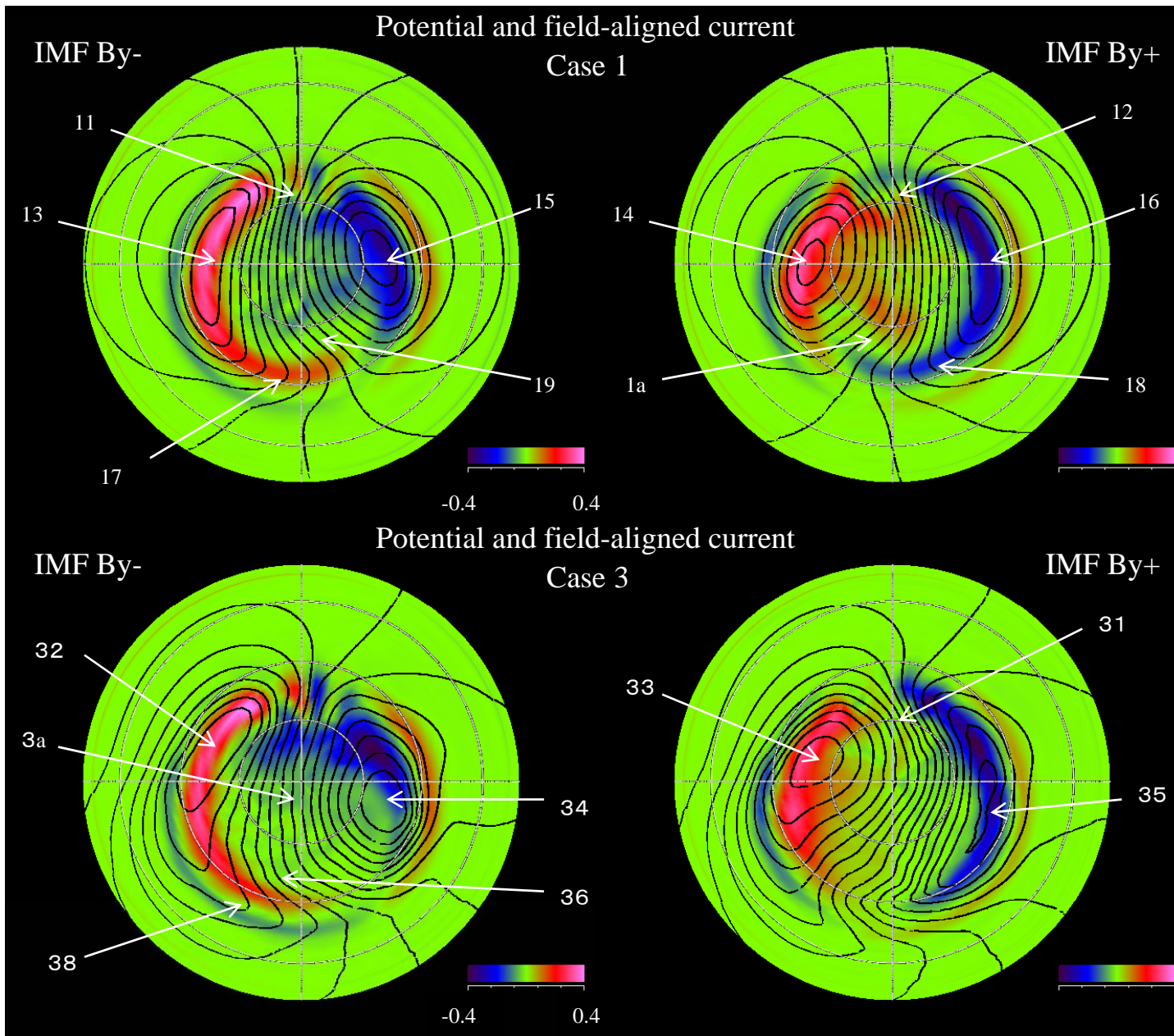
$$\mathbf{J} \cdot \mathbf{E} < 0$$

- 電離圏closureが成立すること

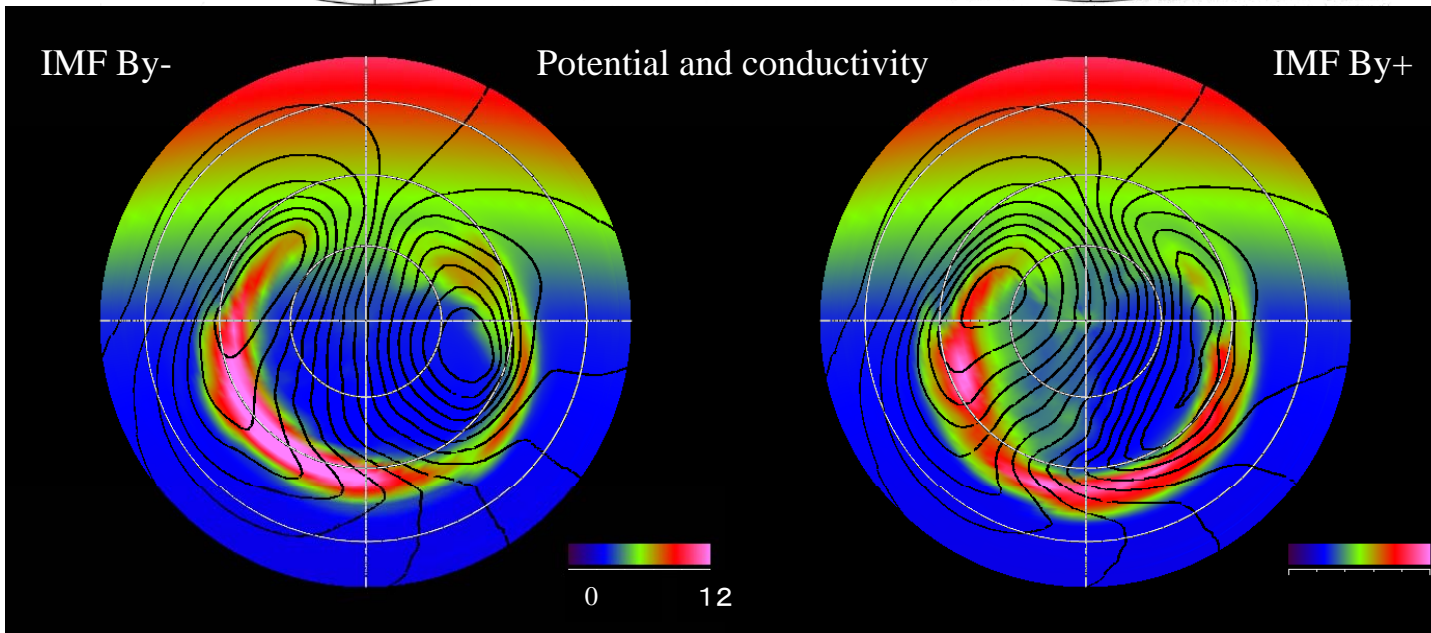
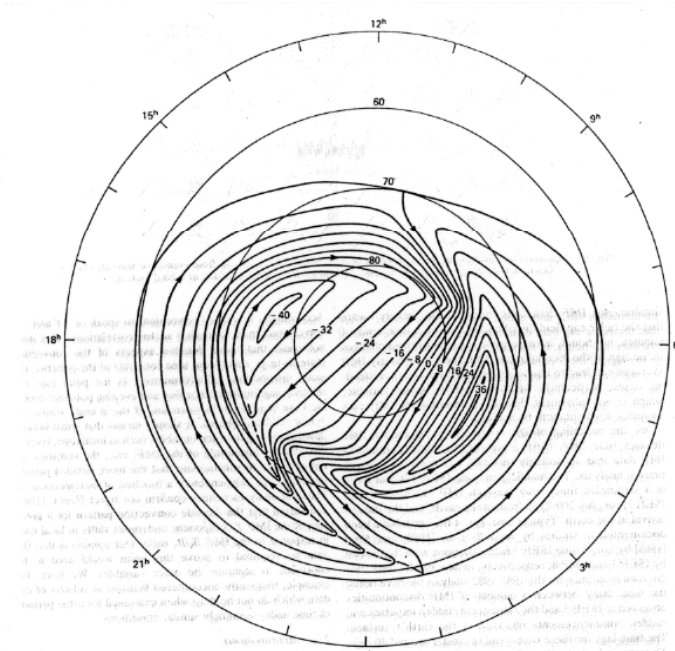
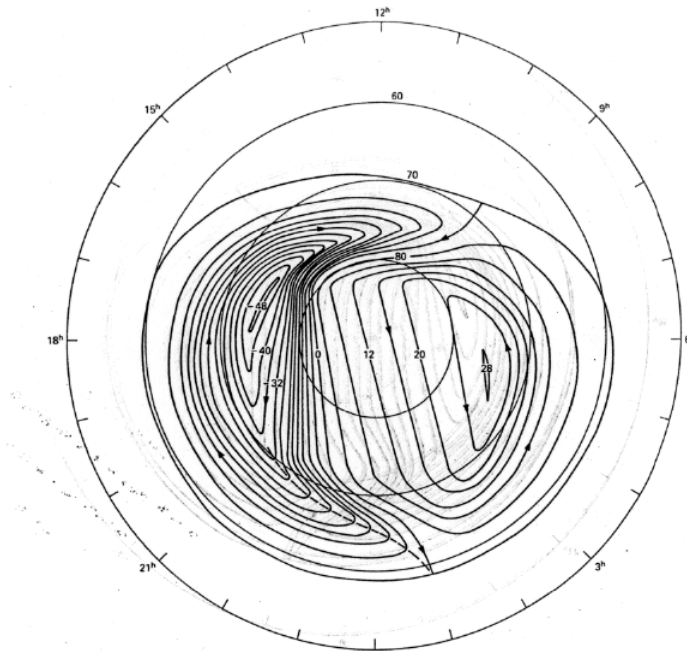
$$\nabla \cdot \Sigma \nabla \varphi = J_{\parallel}$$

$\mathbf{v}, \mathbf{E}, \varphi \rightarrow$ 同一物理量

Convection pattern and FAC (IMF By dependence)



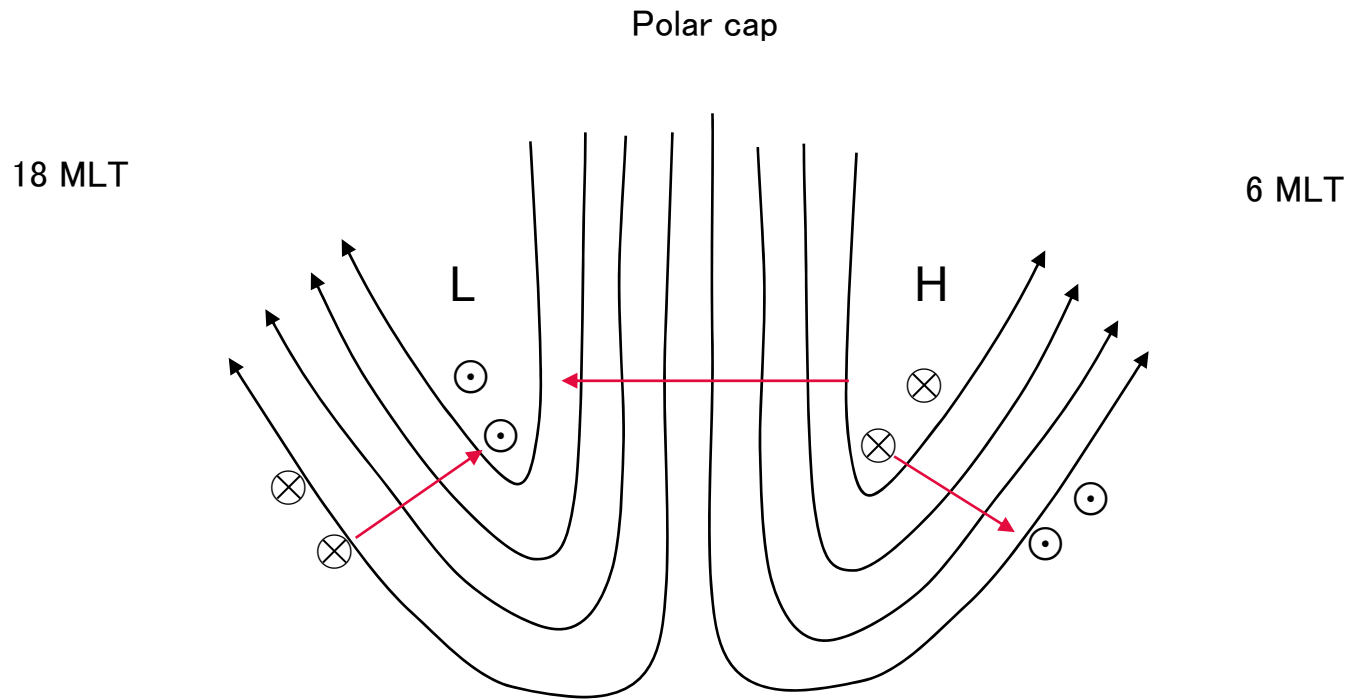
Heppner-Maynard convection pattern



Convection pattern and FAC

Ionospheric closure with uniform Σ

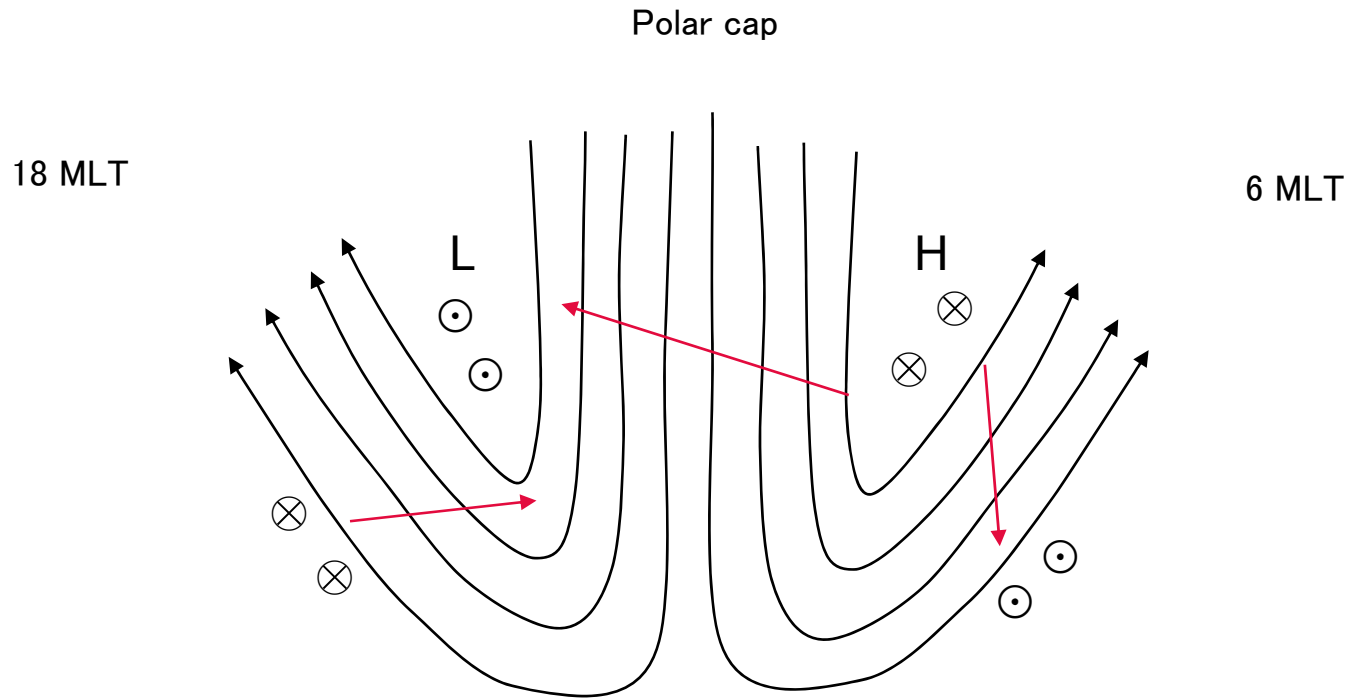
H: high potential, L: low potential



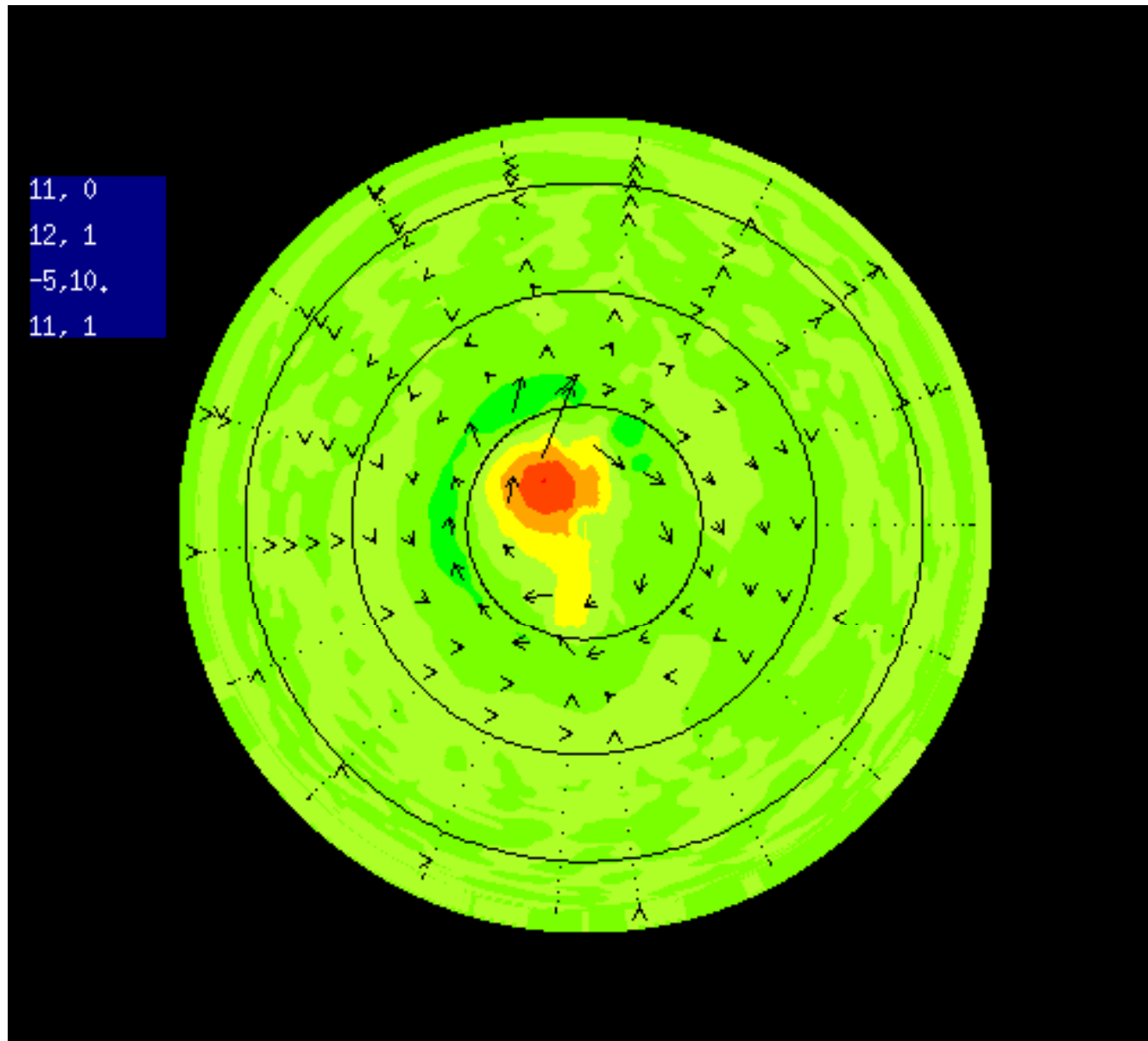
Convection pattern and FAC

Ionospheric closure with non-uniform Σ

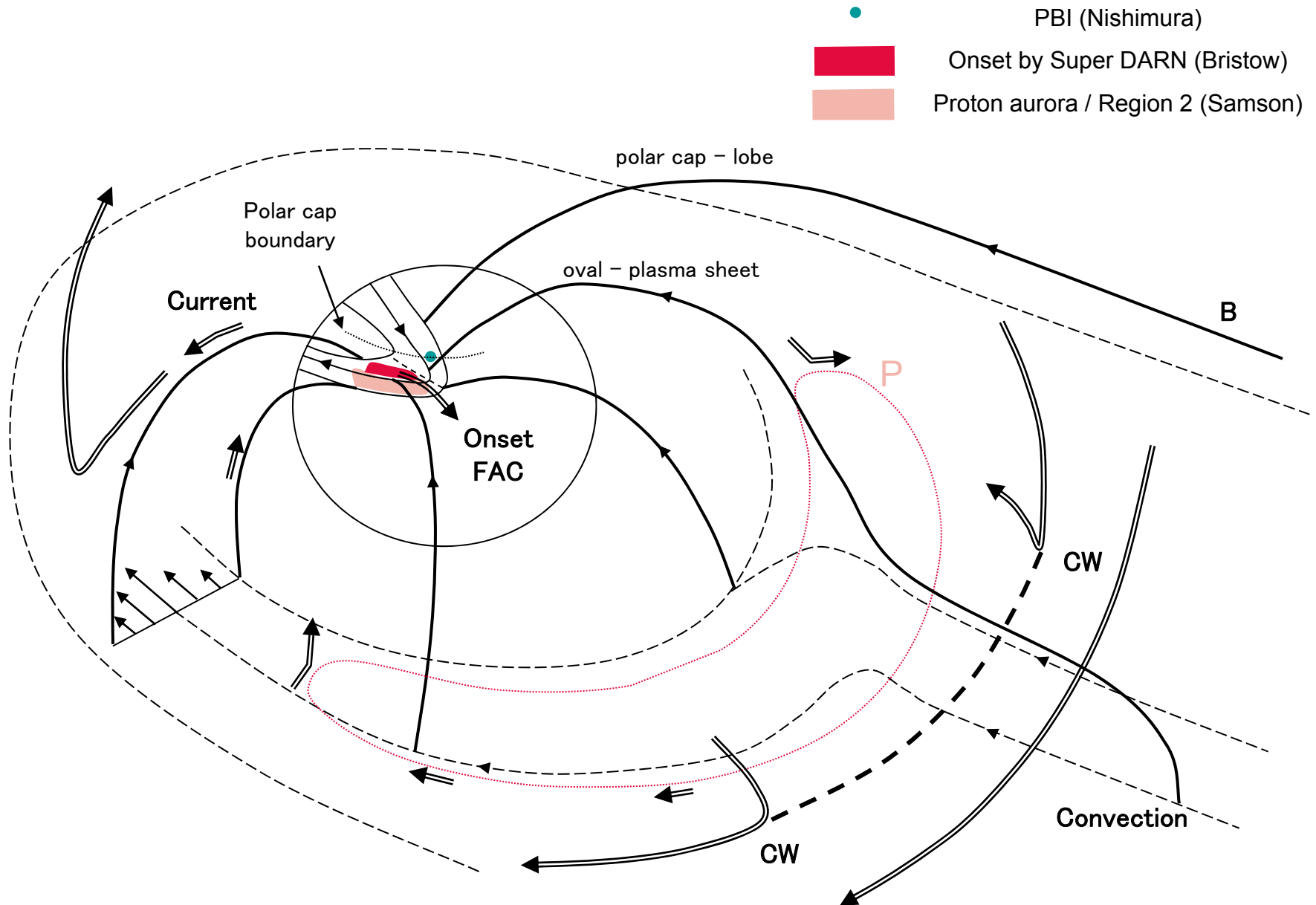
H: high potential, L: low potential



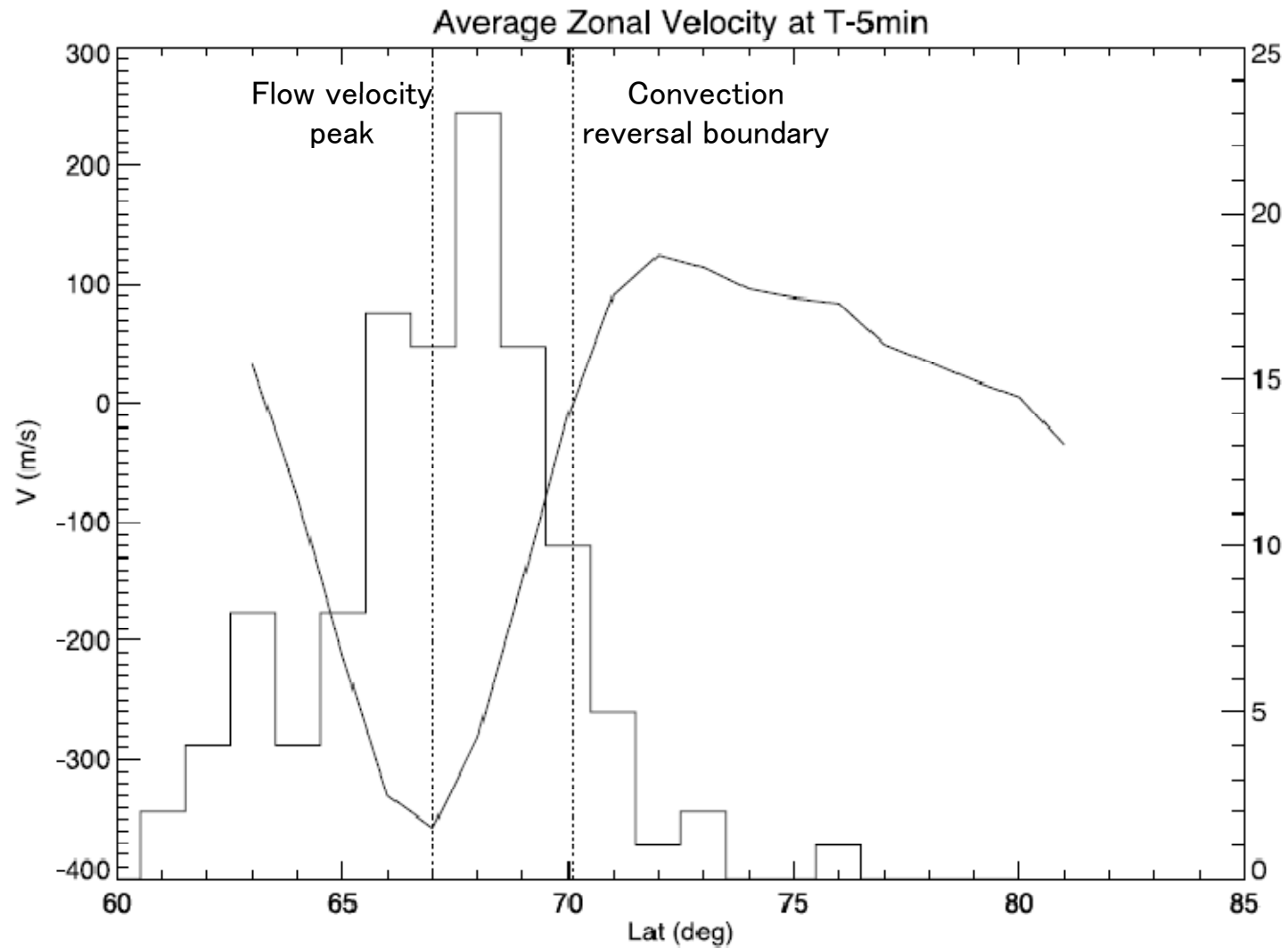
Substorm currents system (color FAC)



Substorm current system and convection

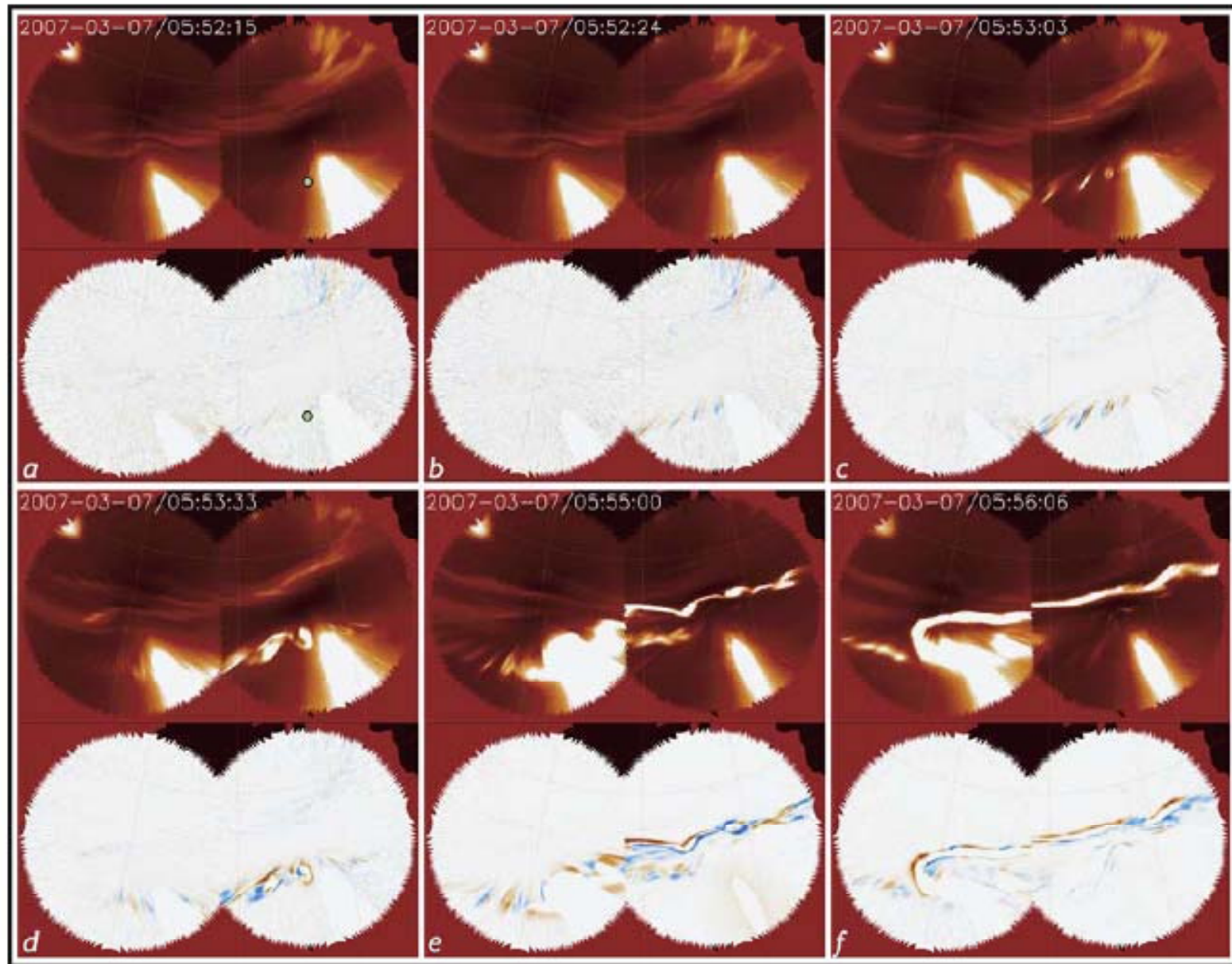


Substorm onset location (Super DARN)



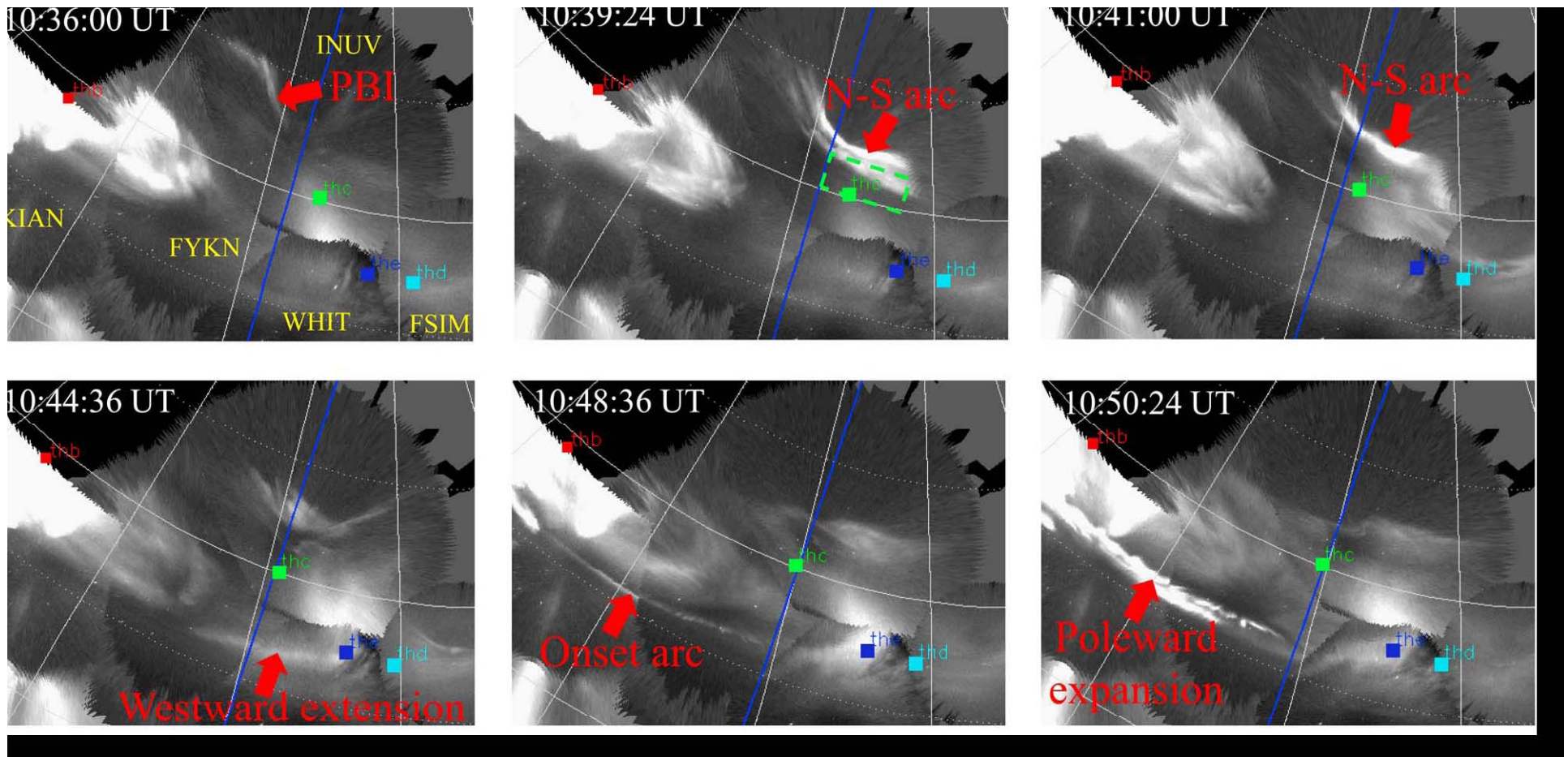
(Bristow, 2009)

Onset arc problem (upper poleward)



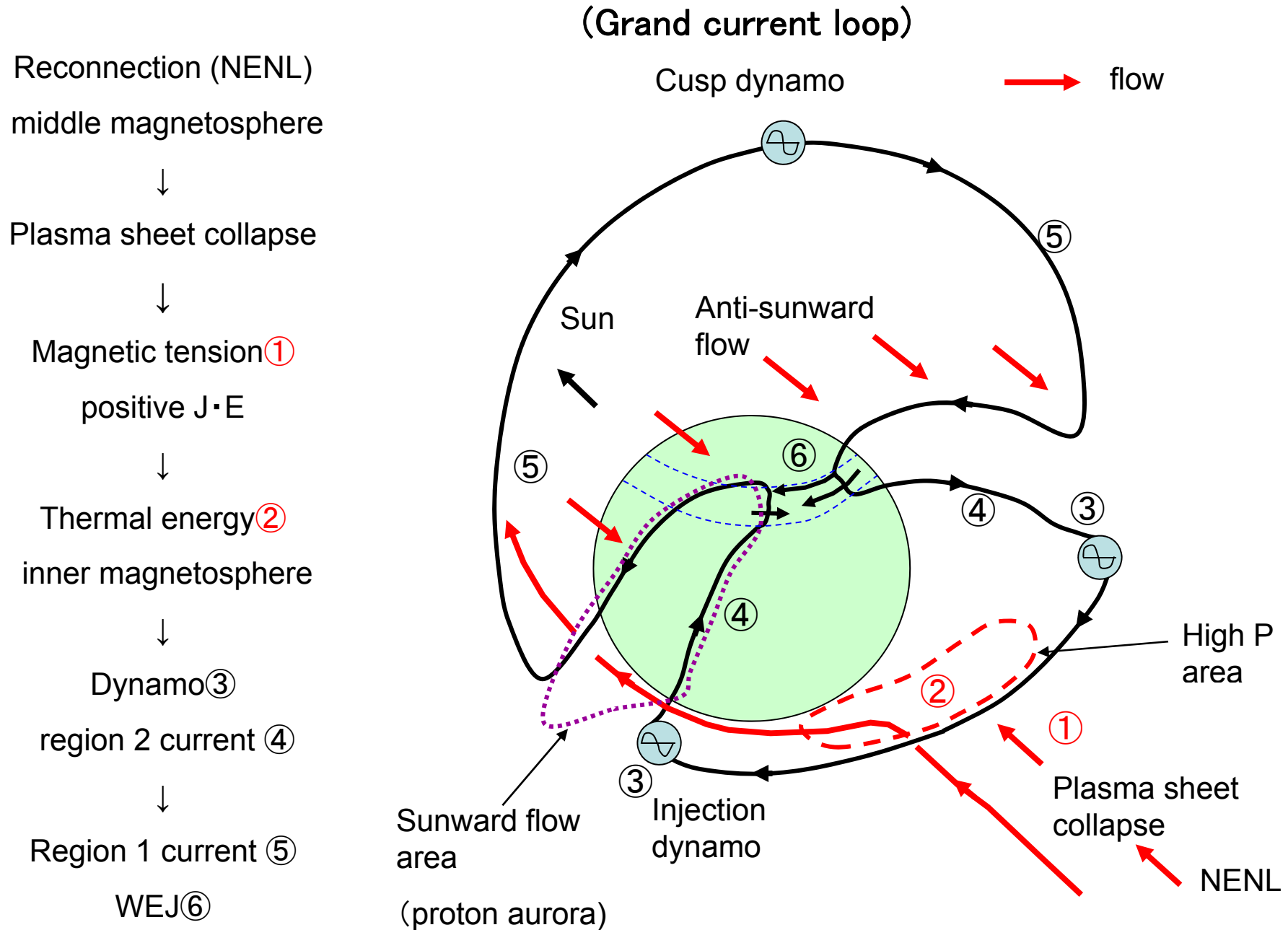
(Rae et al., 2009)

N-S arc and substorm onset



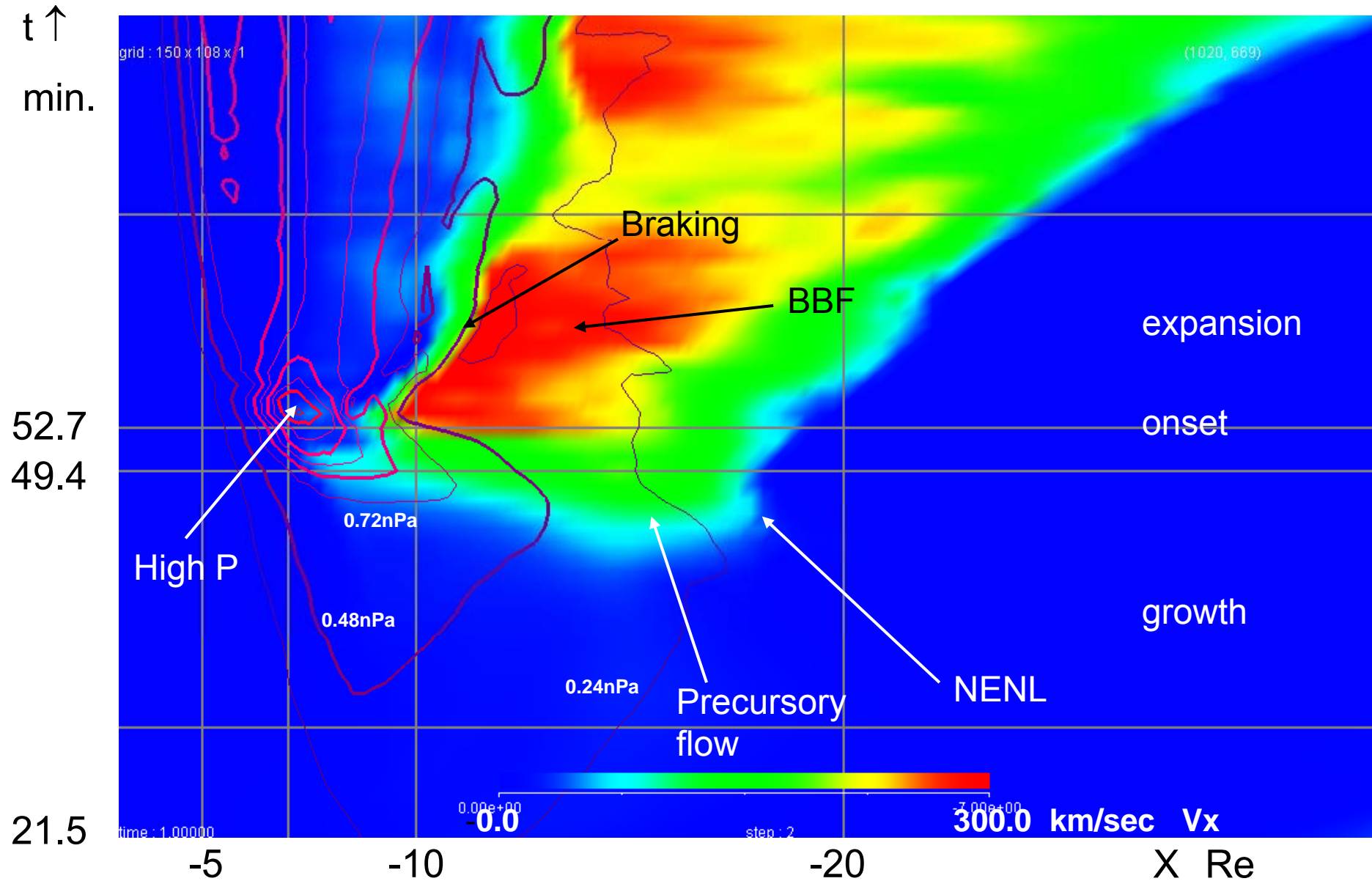
(Xing et al., 2010)

Region 2 current driven model of the substorm

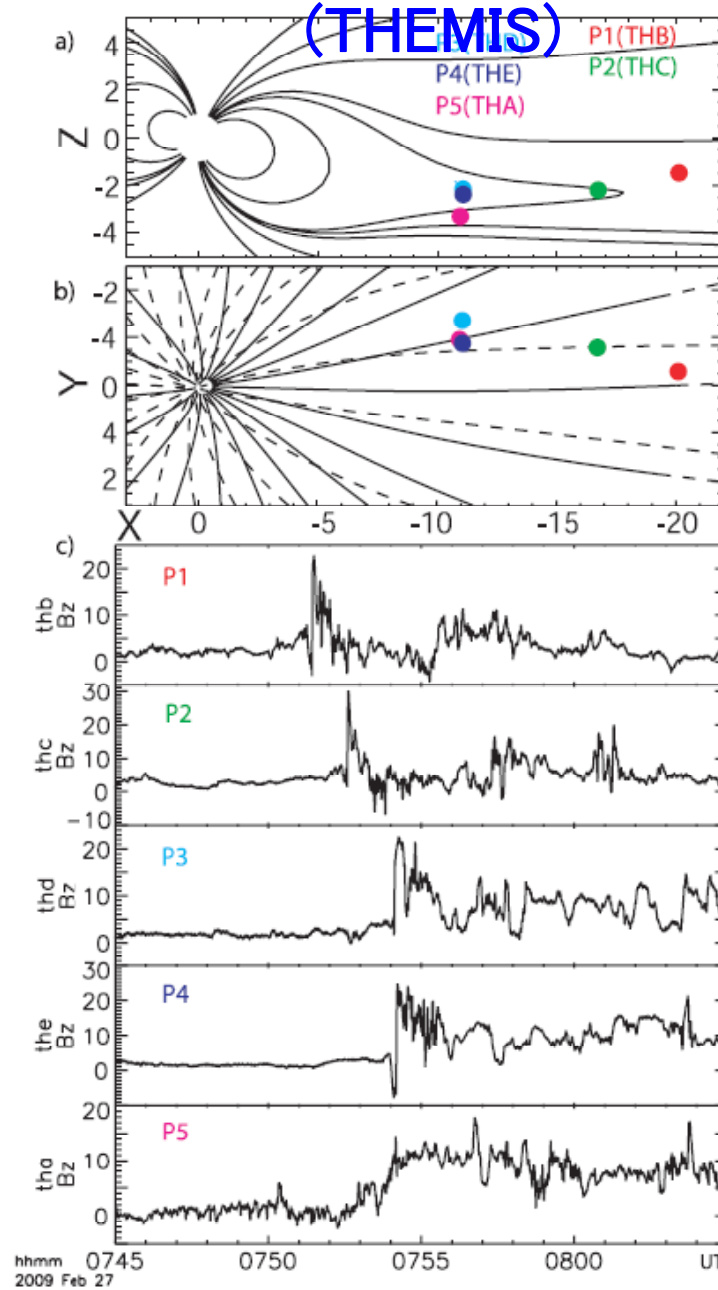


Developments of precursory flow and pressure

(Color: V_x at $y=z=0$, Contour: P at $y=z=0$ interval 240 pPa)



Earthward propagating dipolarization front

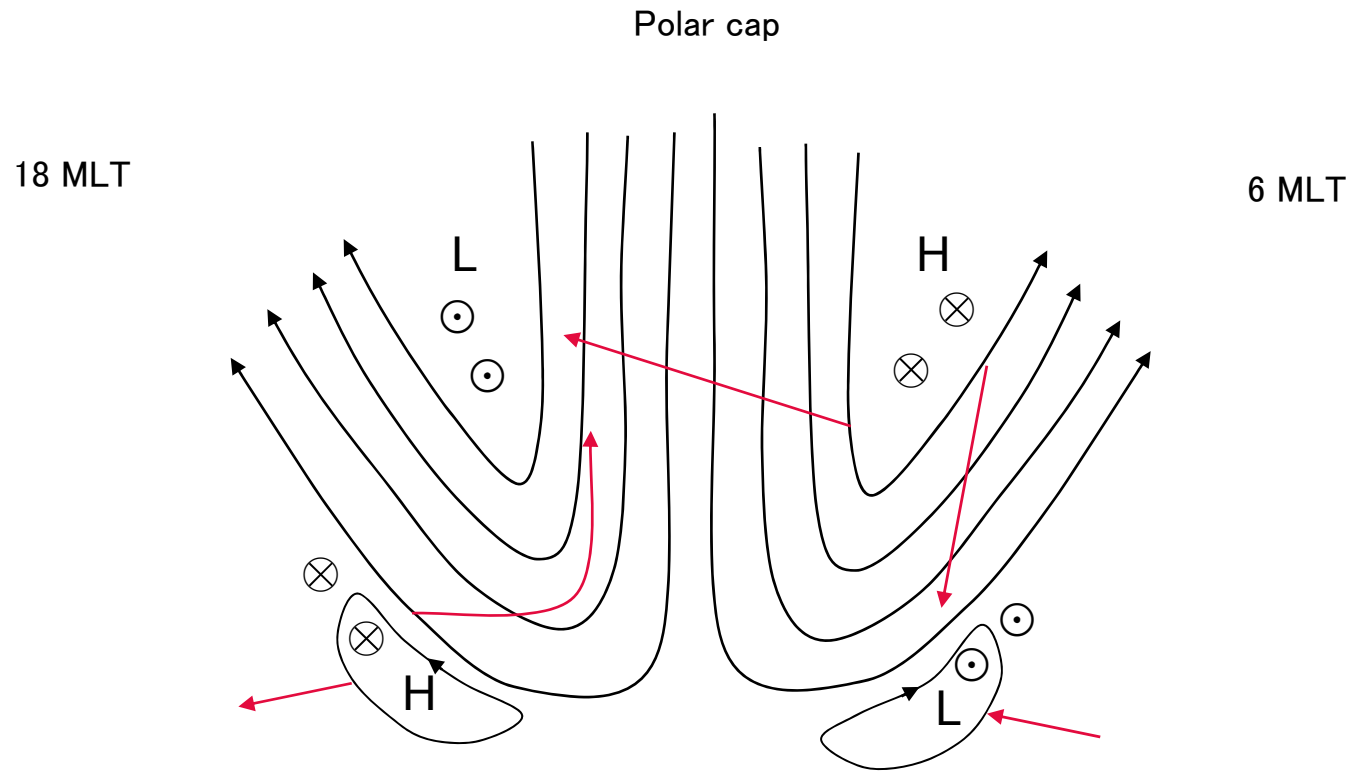


(Runov et al., 2009)

Convection pattern and substorm FAC

Onset → SAPS → CEJ

H: high potential, L: low potential

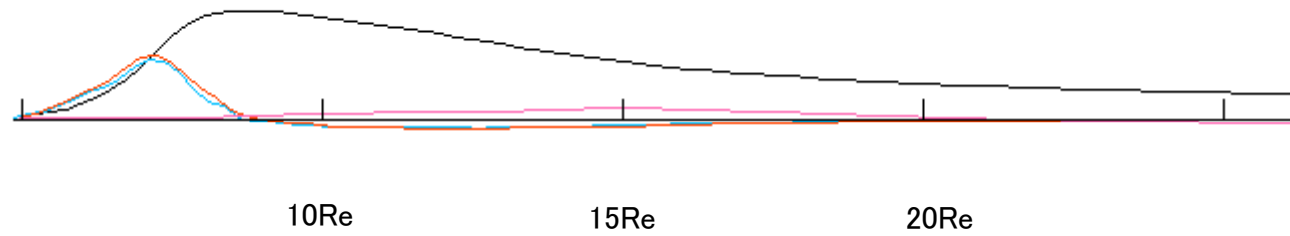


Force balance (34)

Force balance and state transition

onset $t=52$ min

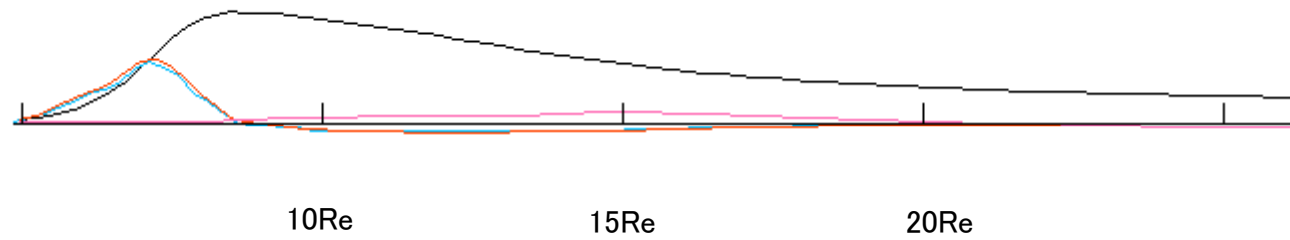
(31/ 3) $t= 32.4$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

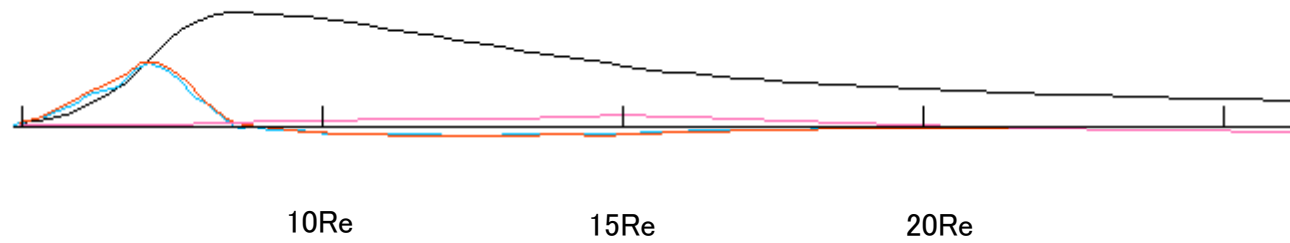
(31/ 4) $t= 33.5$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

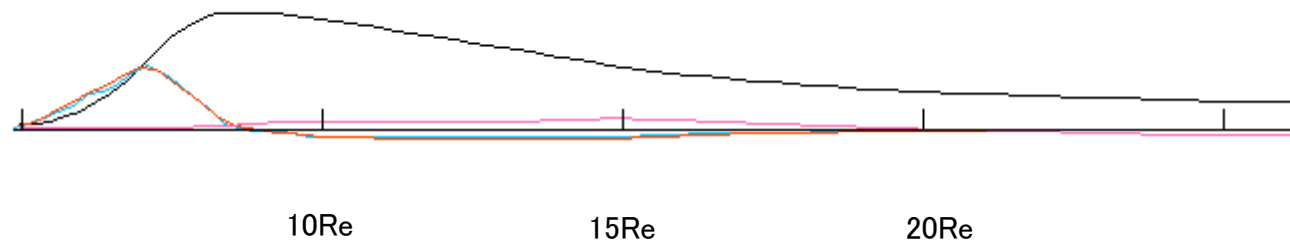
(31/ 5) $t= 34.7$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

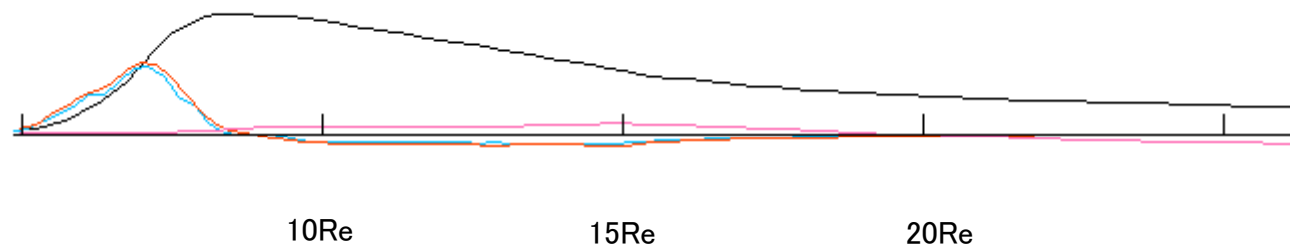
(31/ 6) $t= 35.8$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

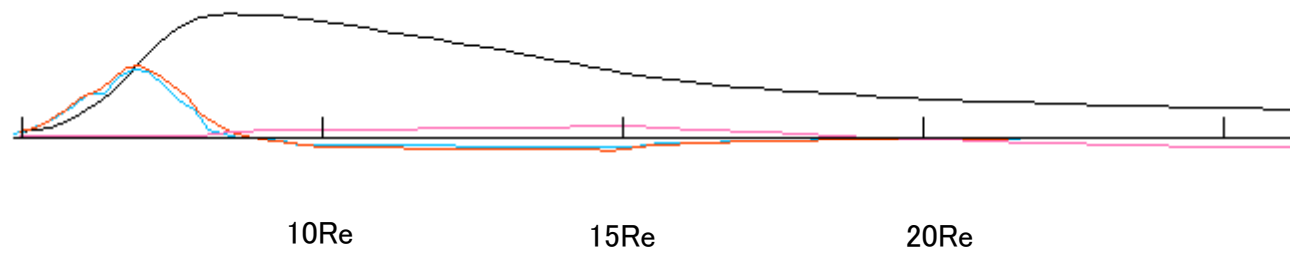
(31/ 7) $t= 37.0$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

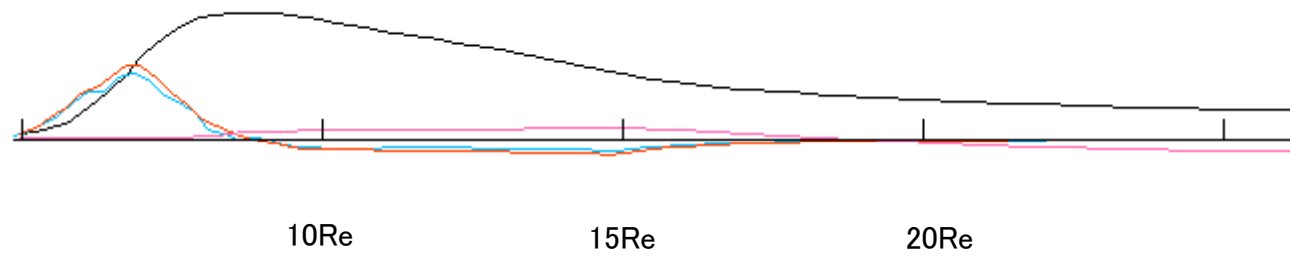
(31/ 8) $t= 38.1$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

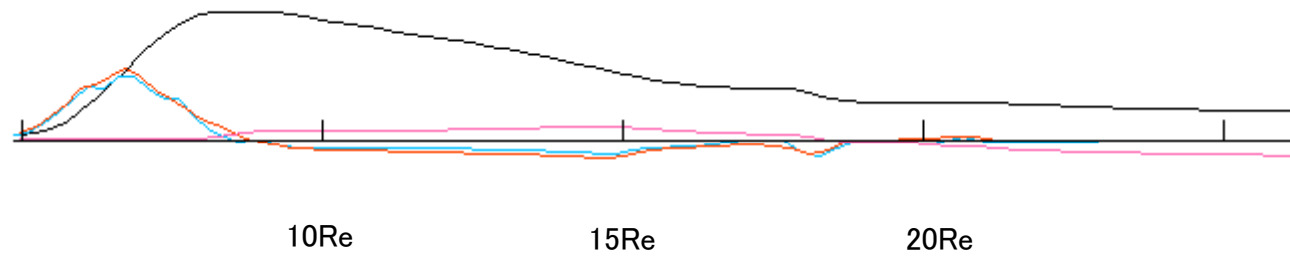
(31/ 9) $t= 39.3$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

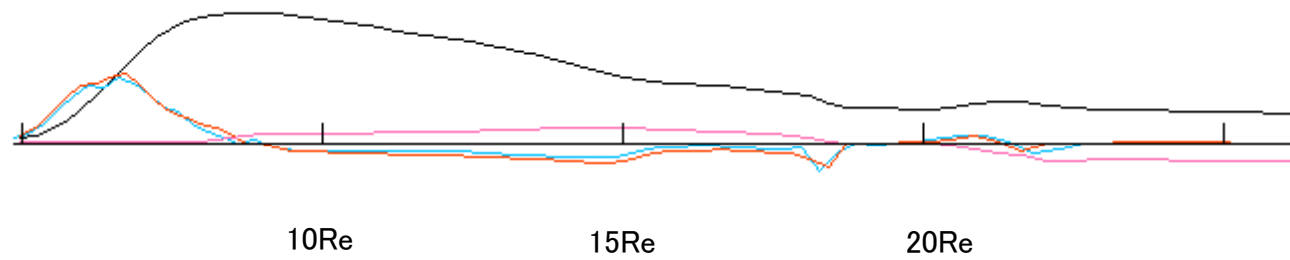
(31/10) $t=40.4$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

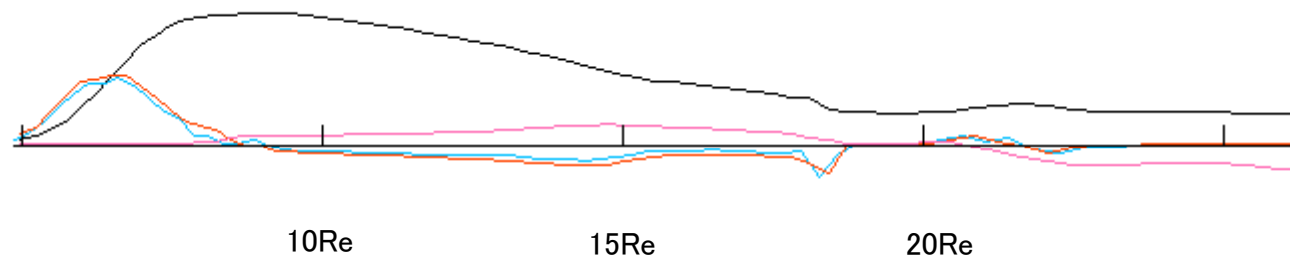
(31/11) $t= 41.5$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

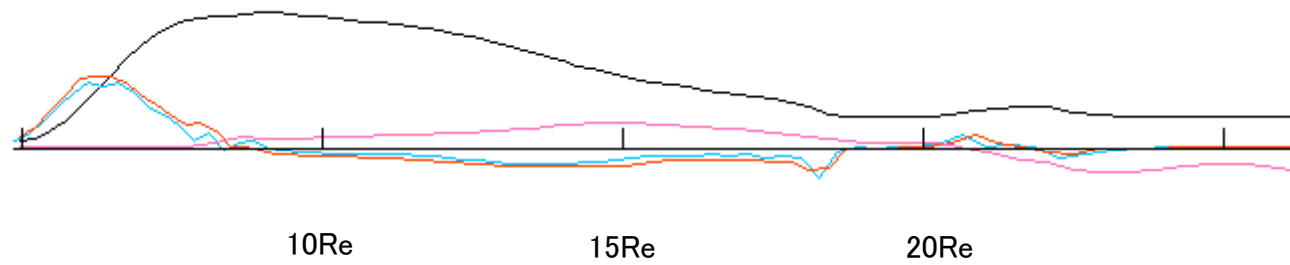
(31/12) $t= 42.7$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

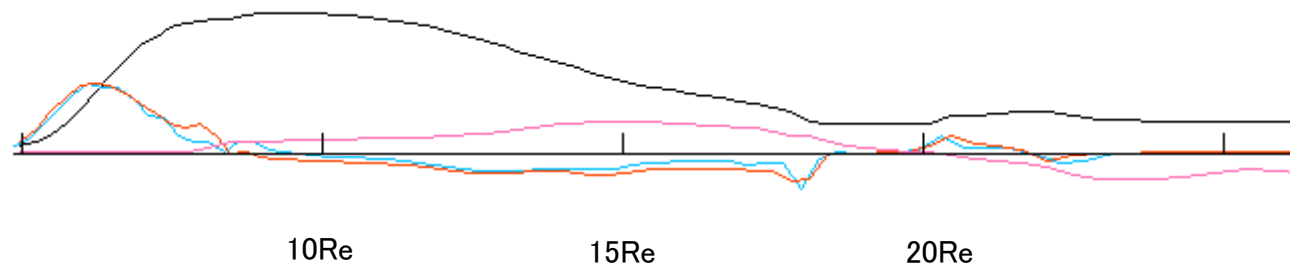
(31/13) $t= 43.8$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

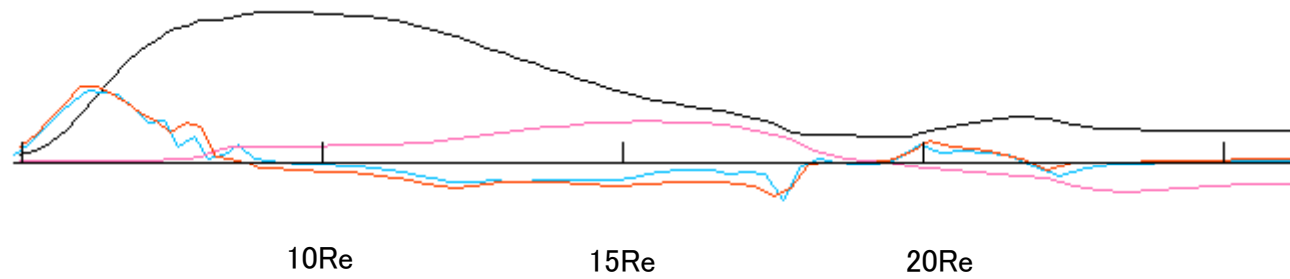
(31/14) $t= 44.9$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

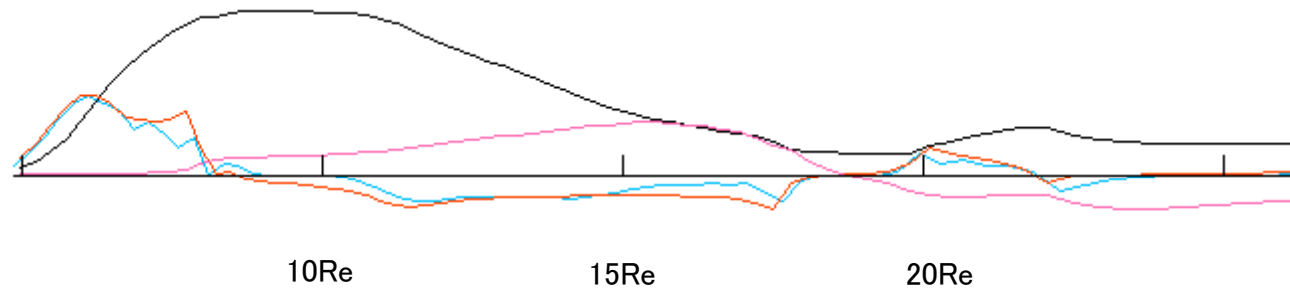
(31/15) $t= 46.1$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

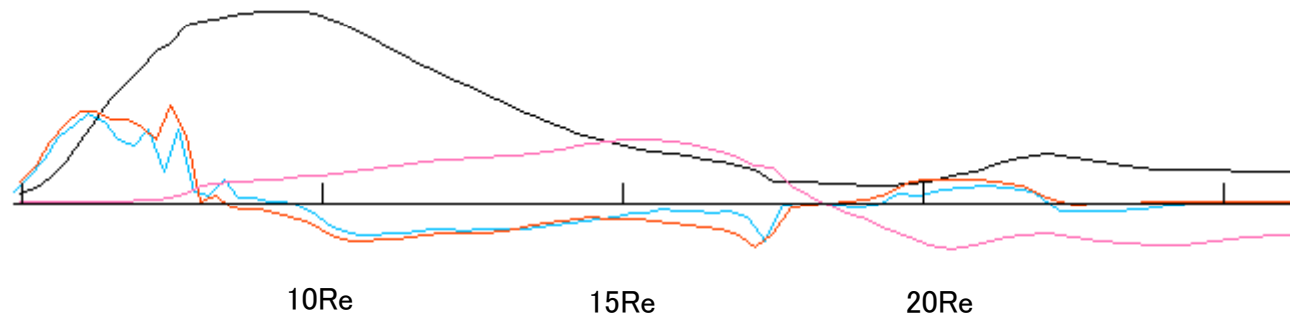
(31/16) $t= 47.2$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

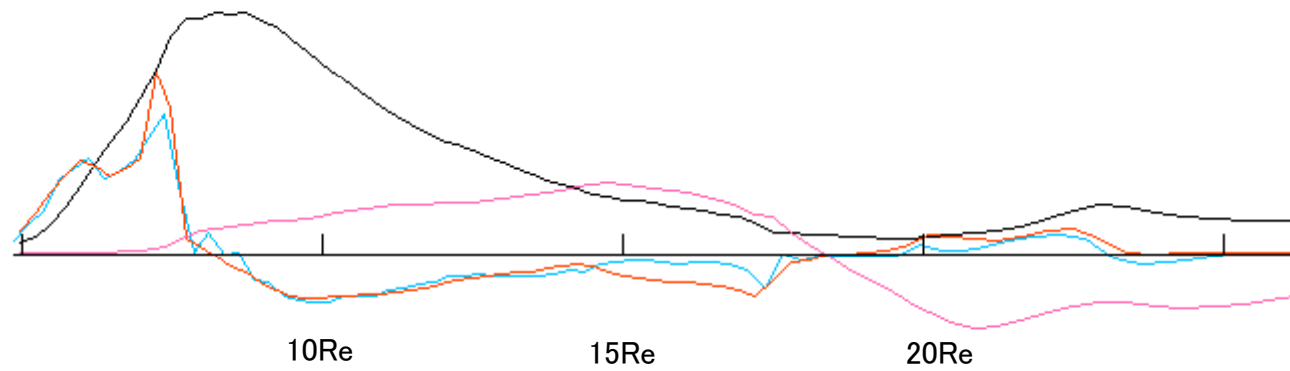
(31/17) $t= 48.3$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

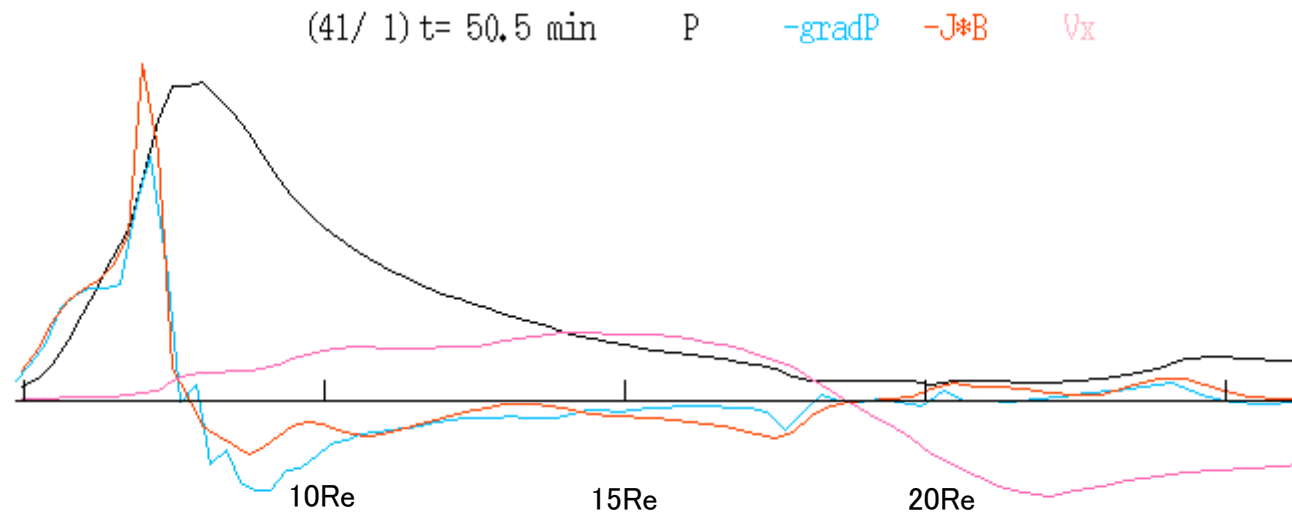
onset $t=52$ min

(31/18) $t= 49.4$ min P $-\text{grad}P$ $-J*B$ V_x



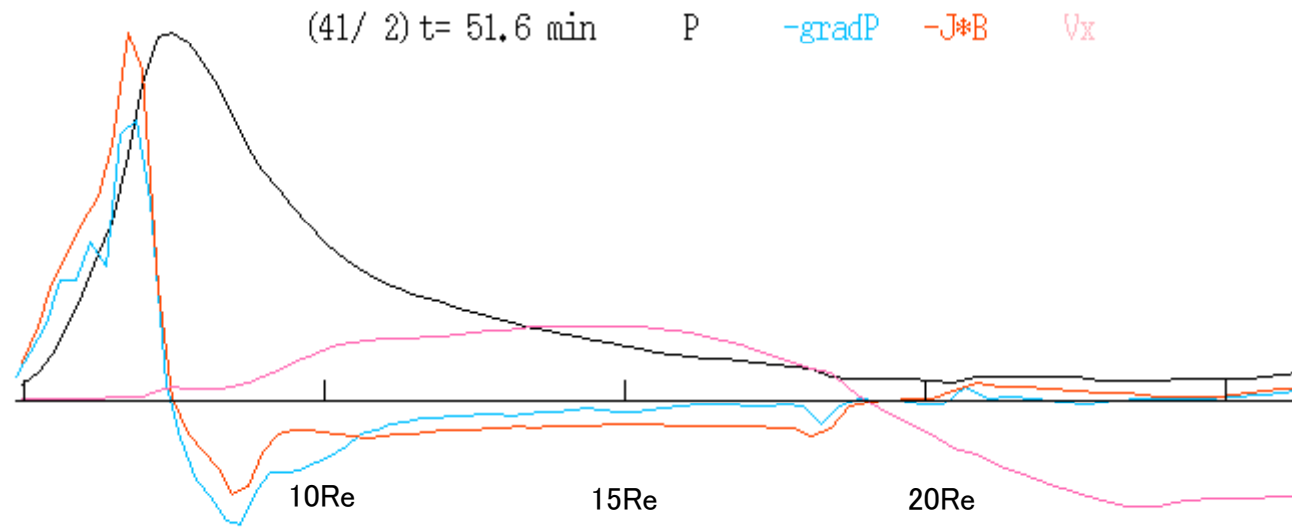
Force balance and state transition

onset $t=52$ min



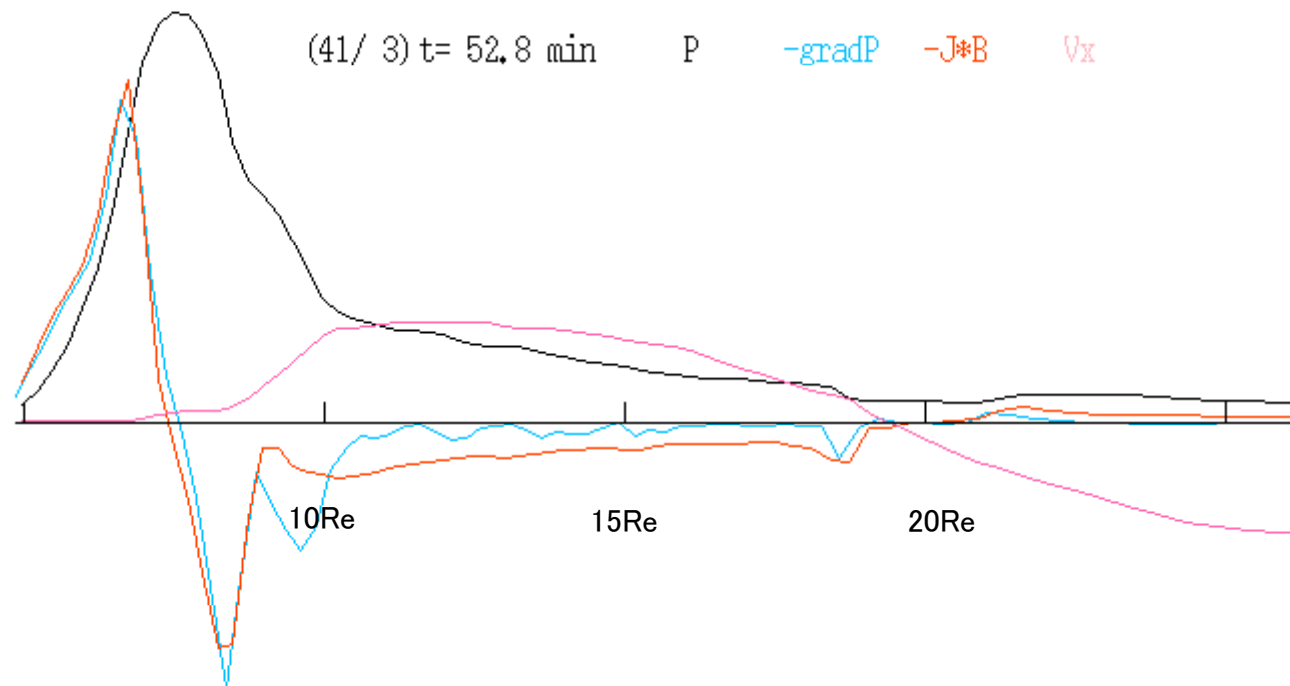
Force balance and state transition

onset $t=52$ min



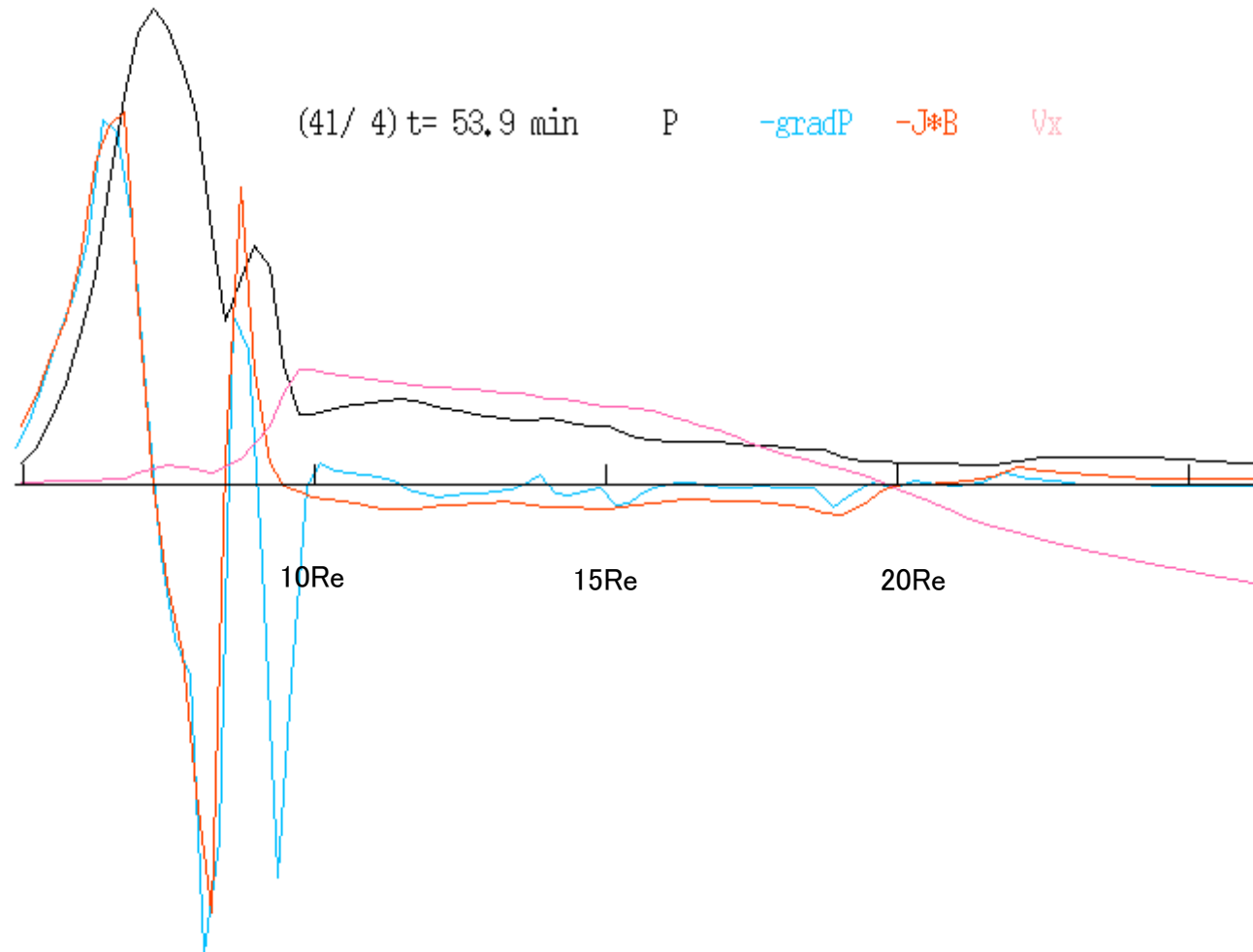
Force balance and state transition

onset $t=52$ min



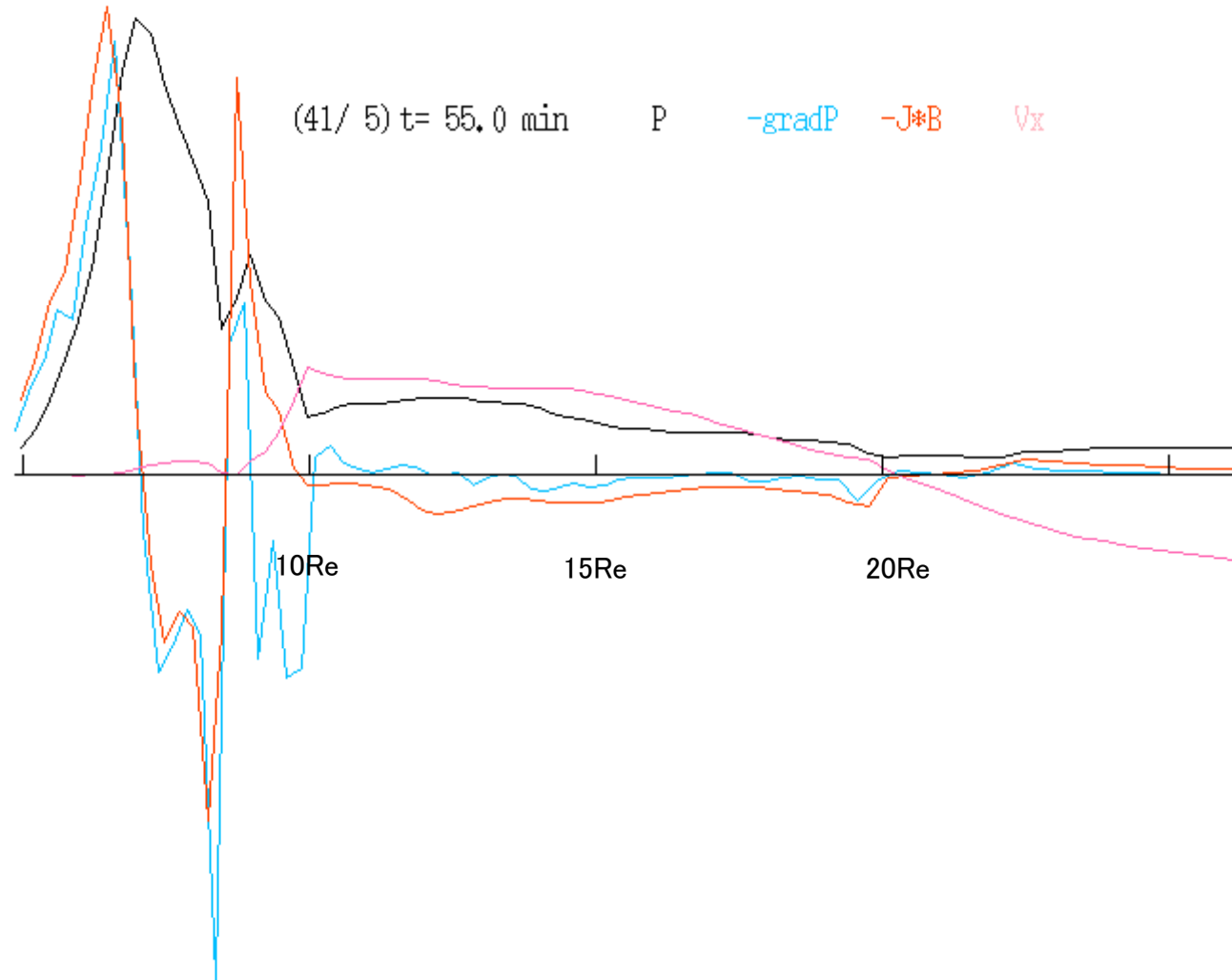
Force balance and state transition

onset $t=52$ min



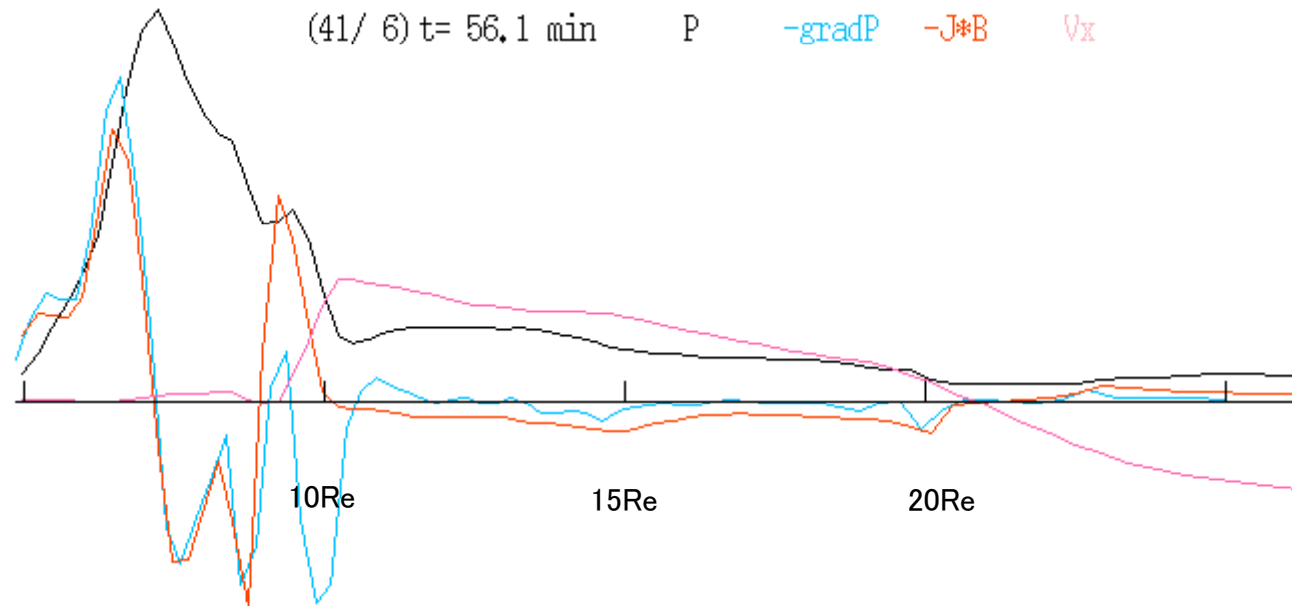
Force balance and state transition

onset $t=52$ min



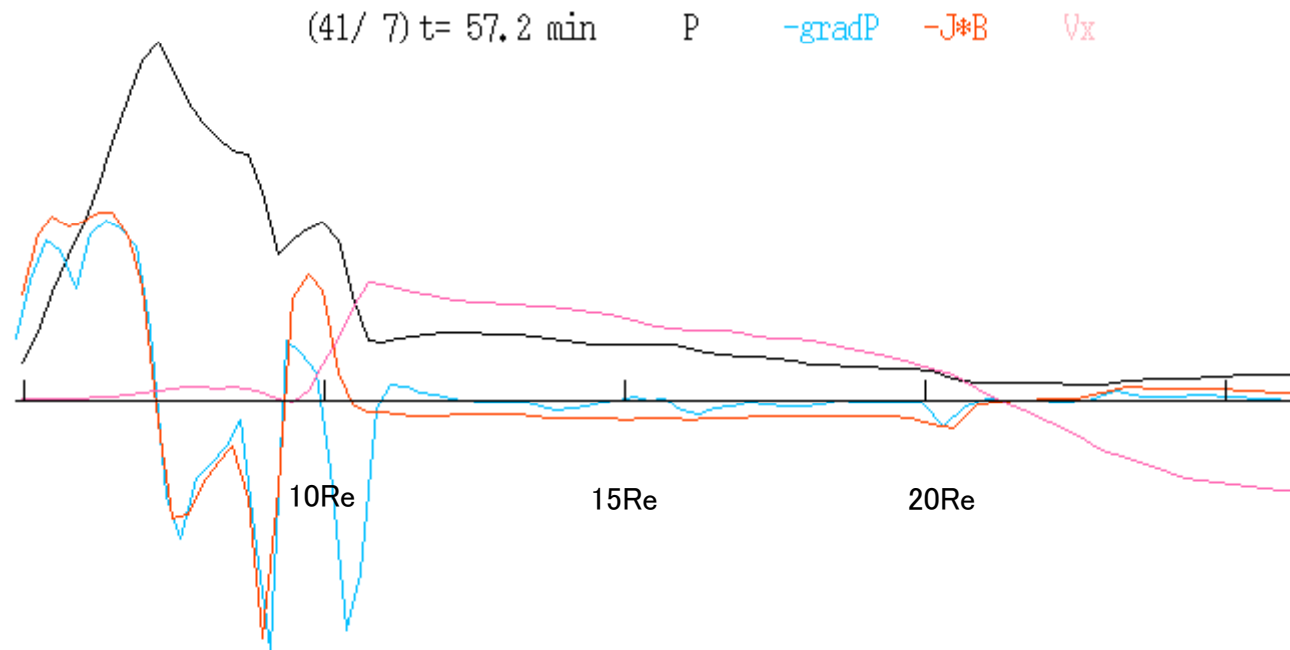
Force balance and state transition

onset $t=52$ min



Force balance and state transition

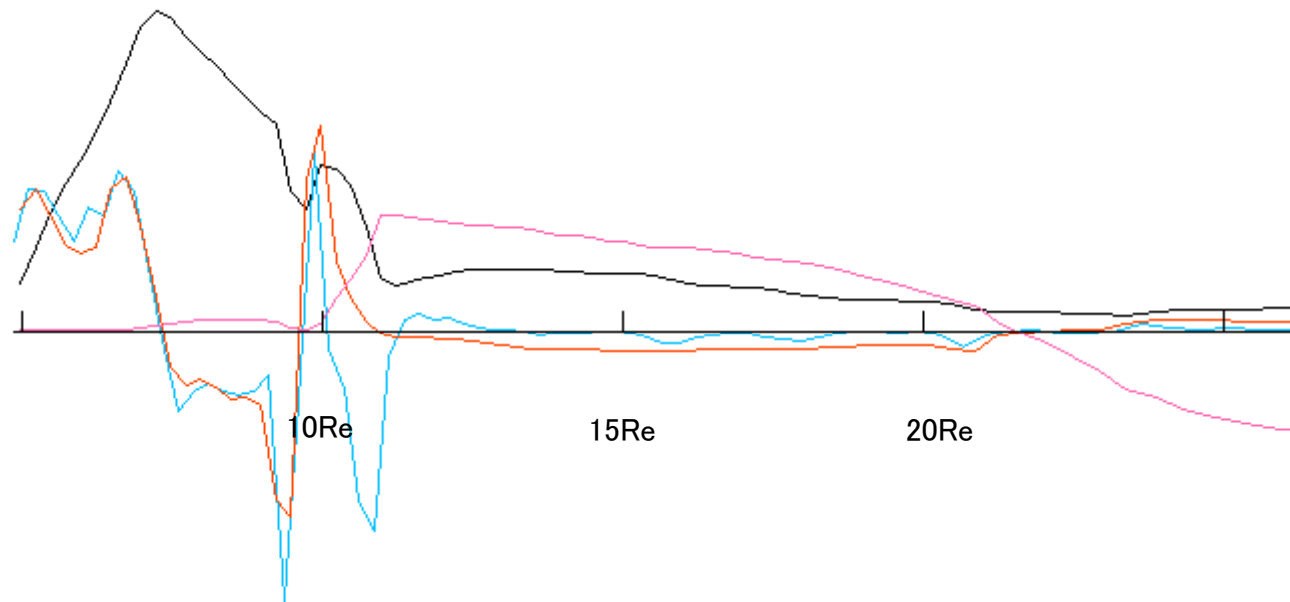
onset $t=52$ min



Force balance and state transition

onset $t=52$ min

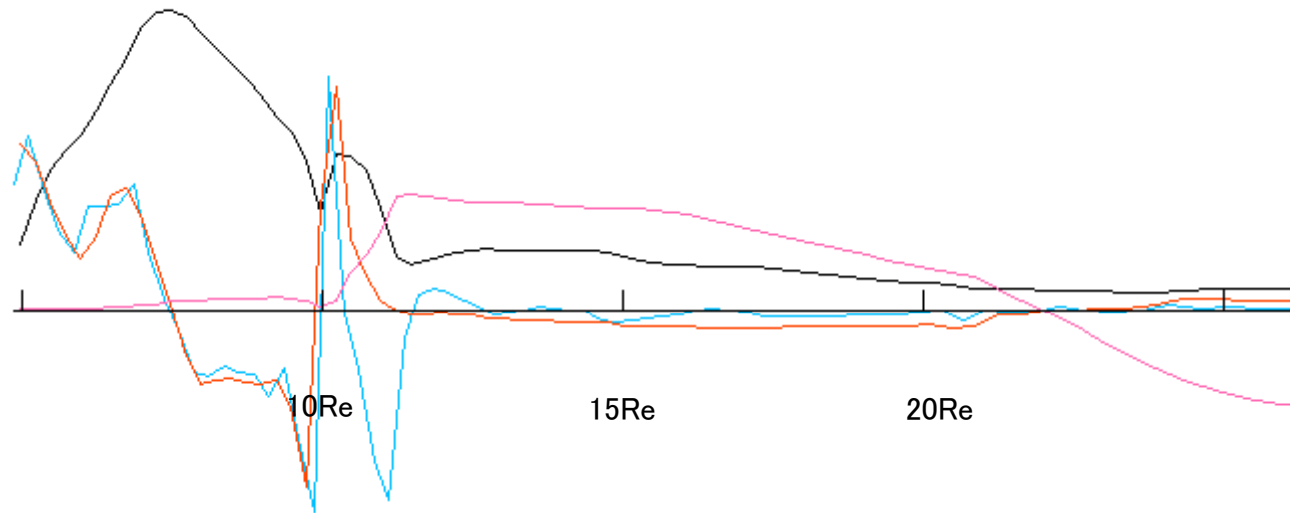
(41/ 8) $t= 58.3$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

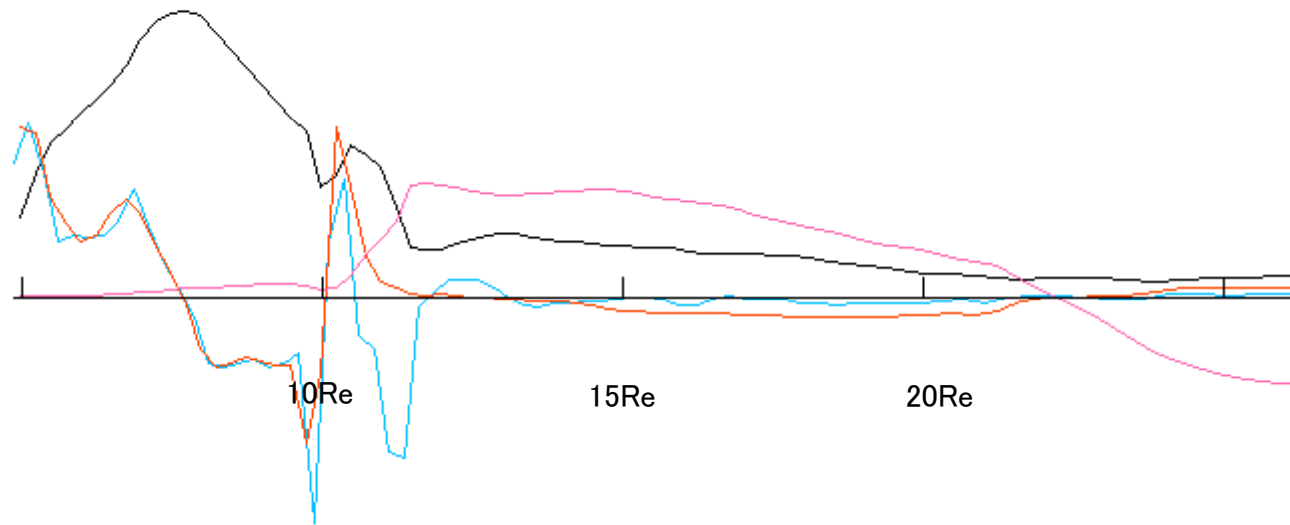
(41/ 9) $t= 59.4$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

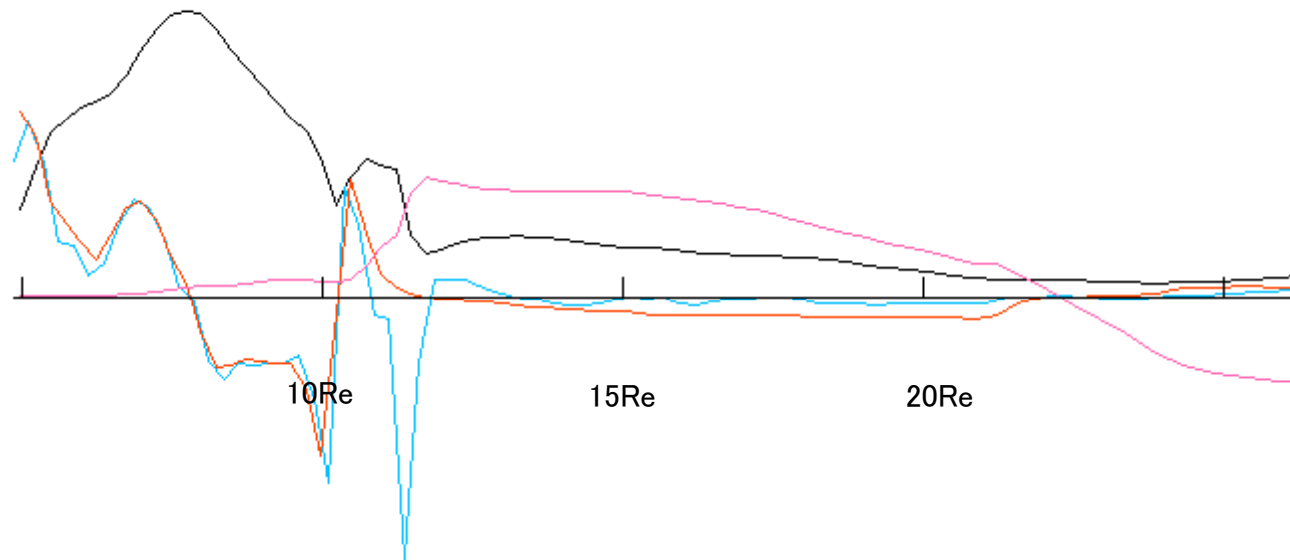
(41/10) $t=60.5$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

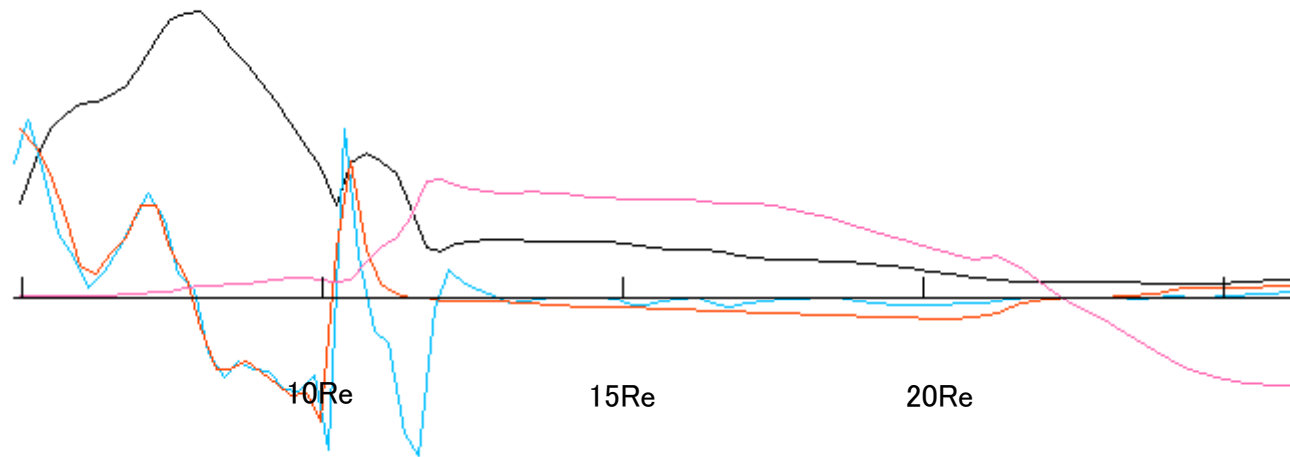
(41/11) $t= 61.6$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

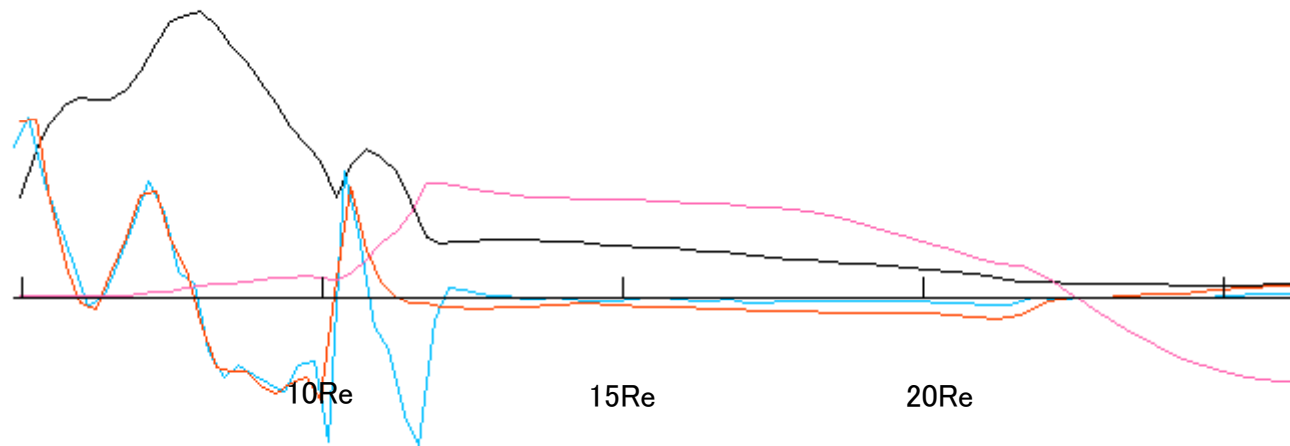
(41/12) $t= 62.7$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

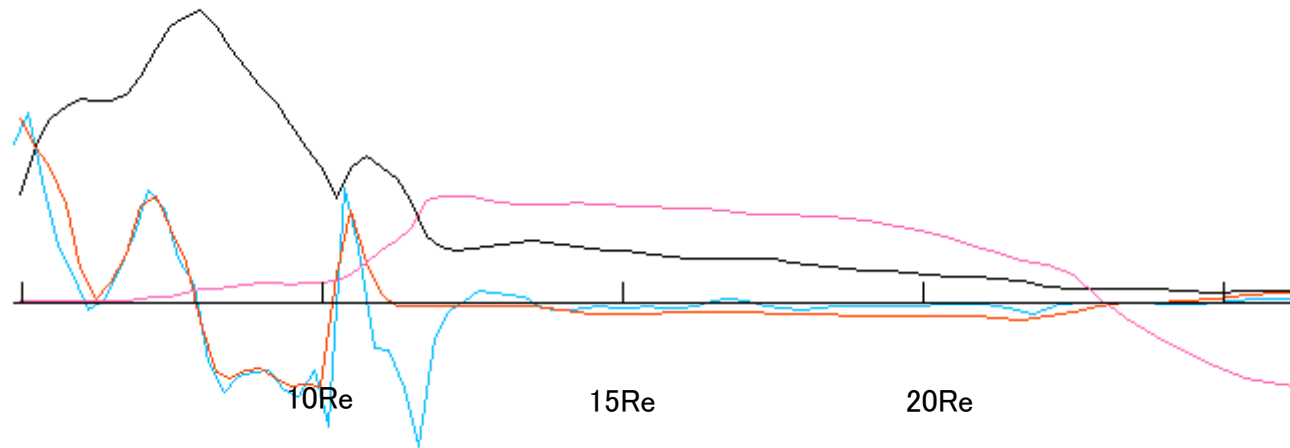
(41/13) $t= 63.8$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

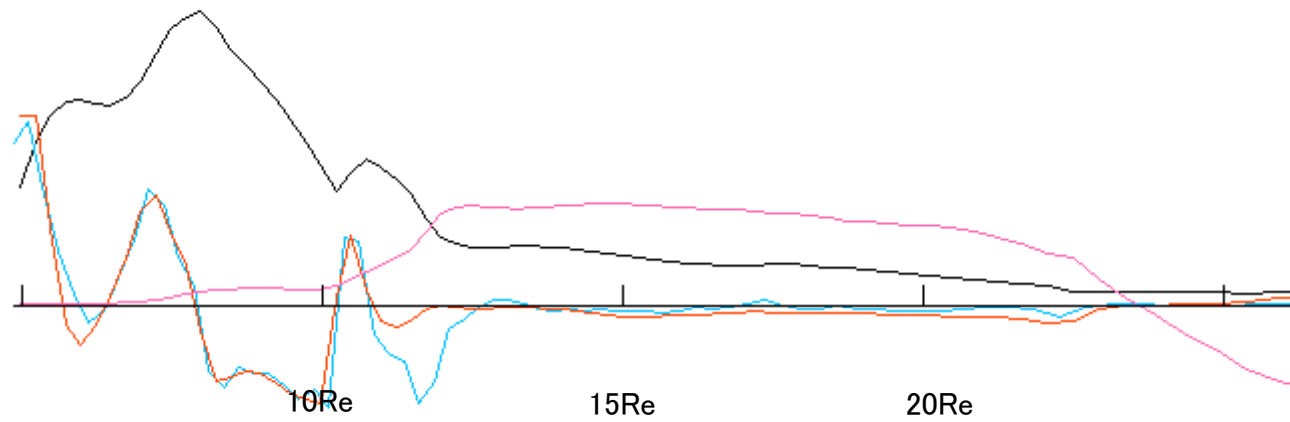
(41/14) $t=64.9$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

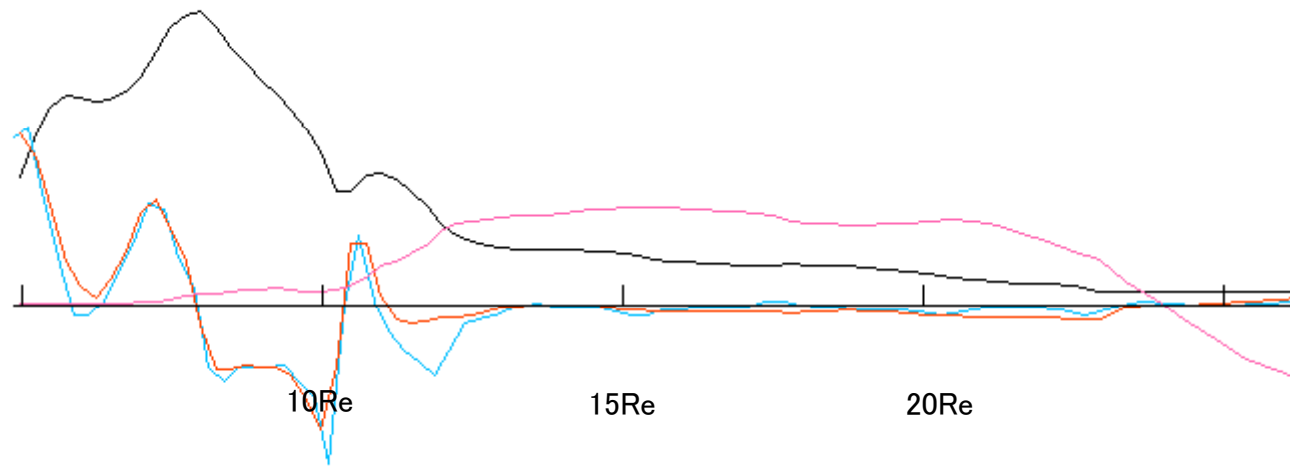
(41/15) $t= 66.0$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

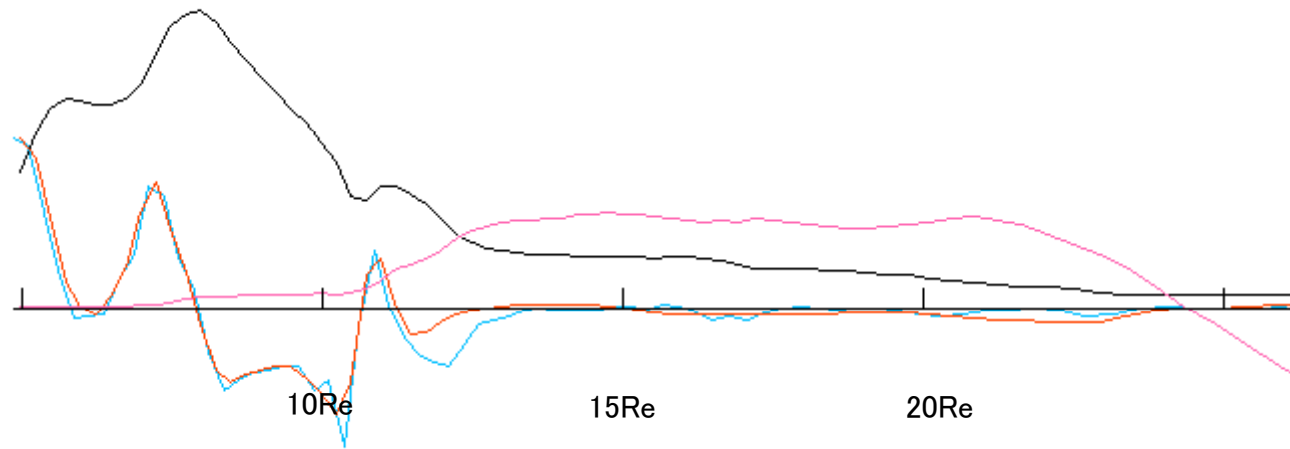
(41/16) $t= 67.1$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

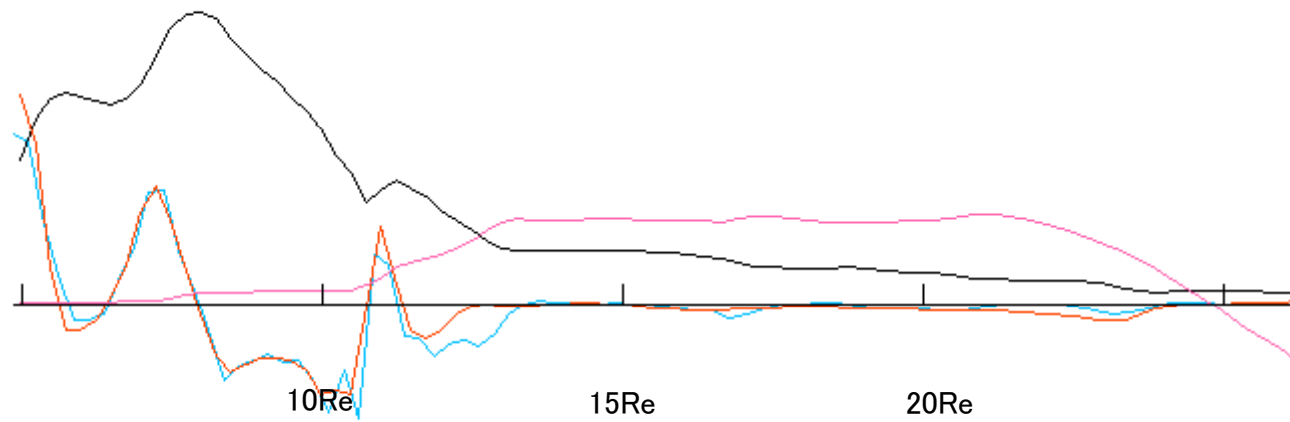
(41/17) $t= 68.2$ min P $-\text{grad}P$ $-J*B$ V_x



Force balance and state transition

onset $t=52$ min

(41/18) $t=69.3$ min P $-\text{grad}P$ $-J*B$ V_x

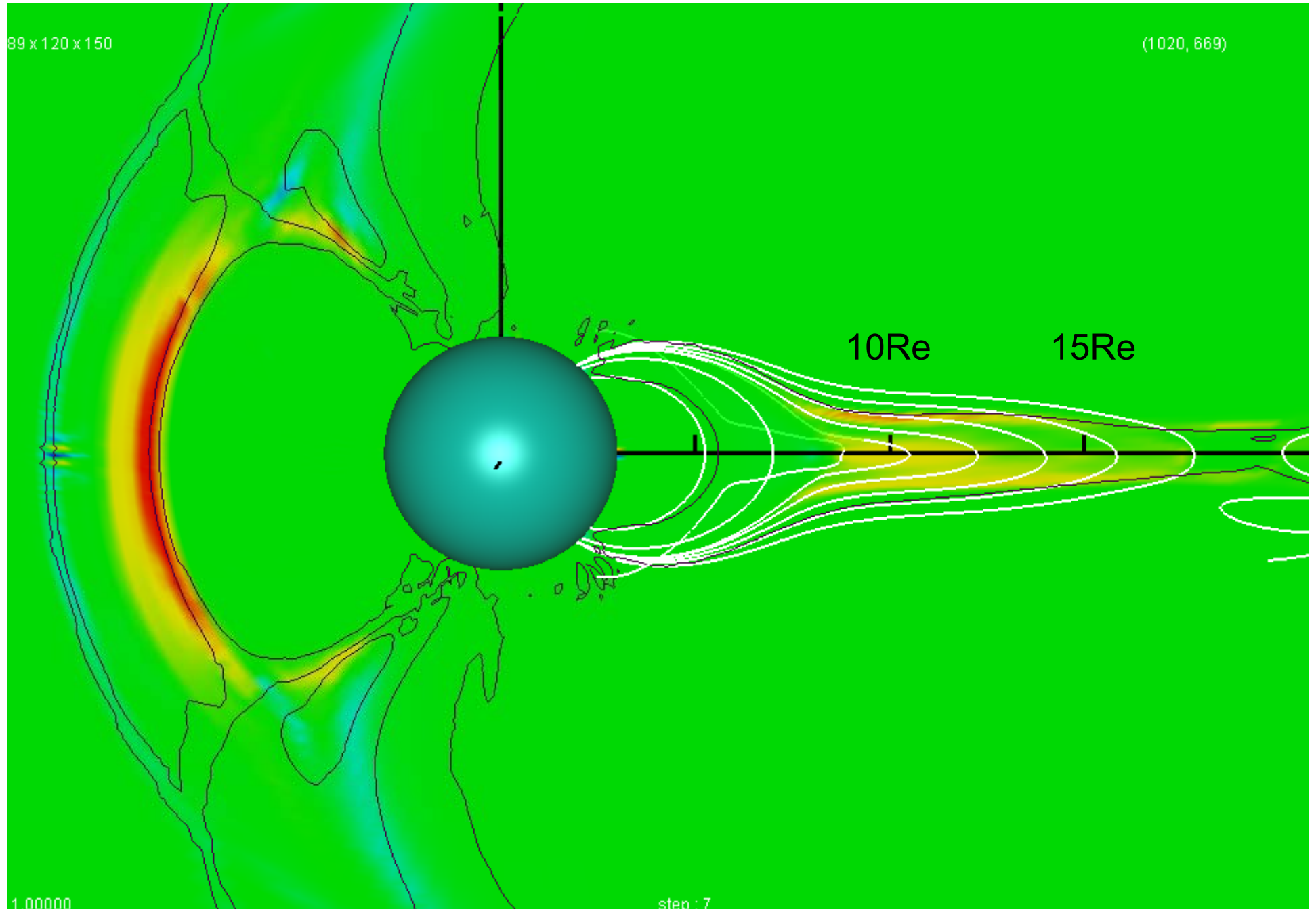


Force balance end (34)

Jy(10)

89 x 120 x 150

(1020, 669)

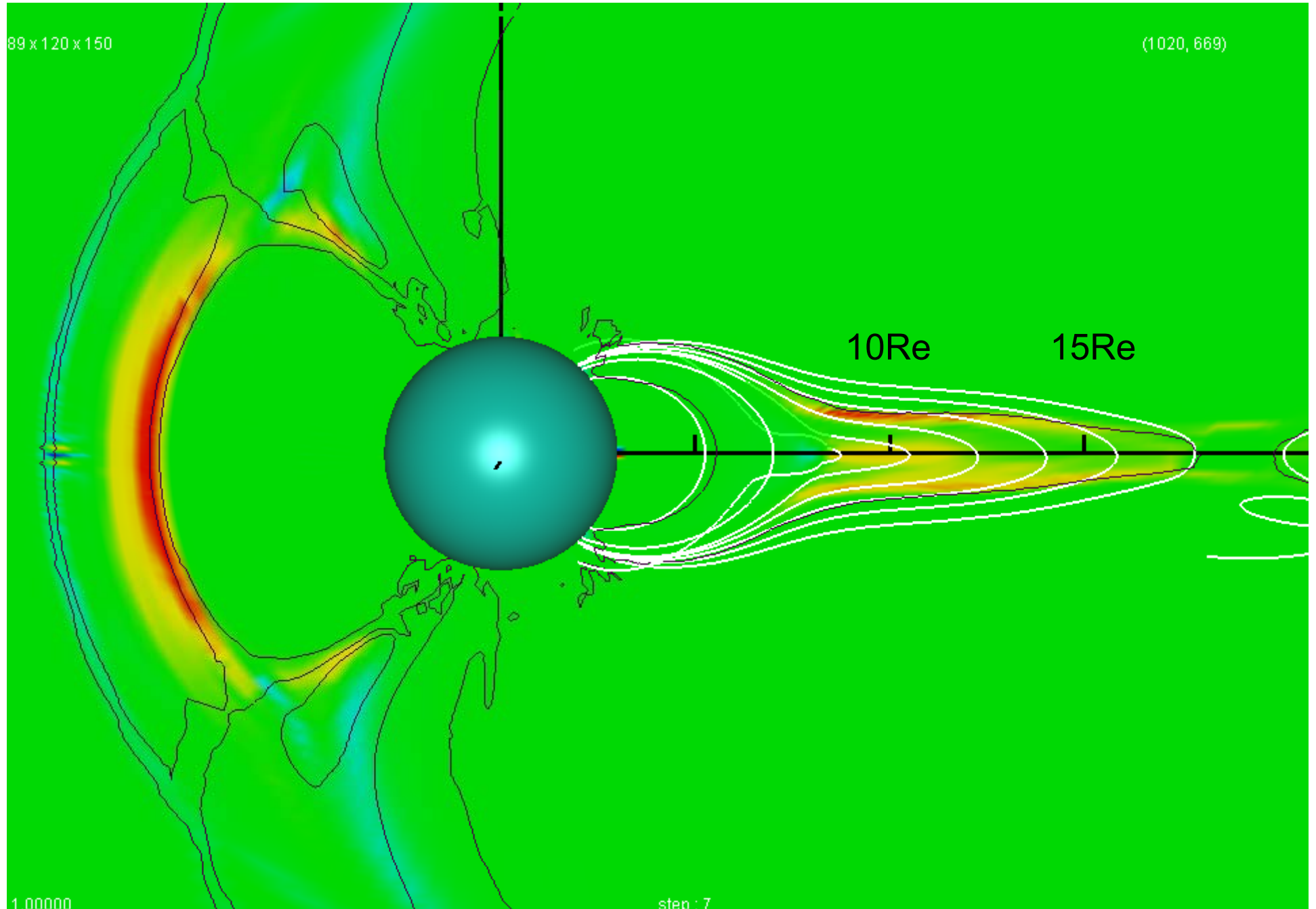


1.00000

step : 7

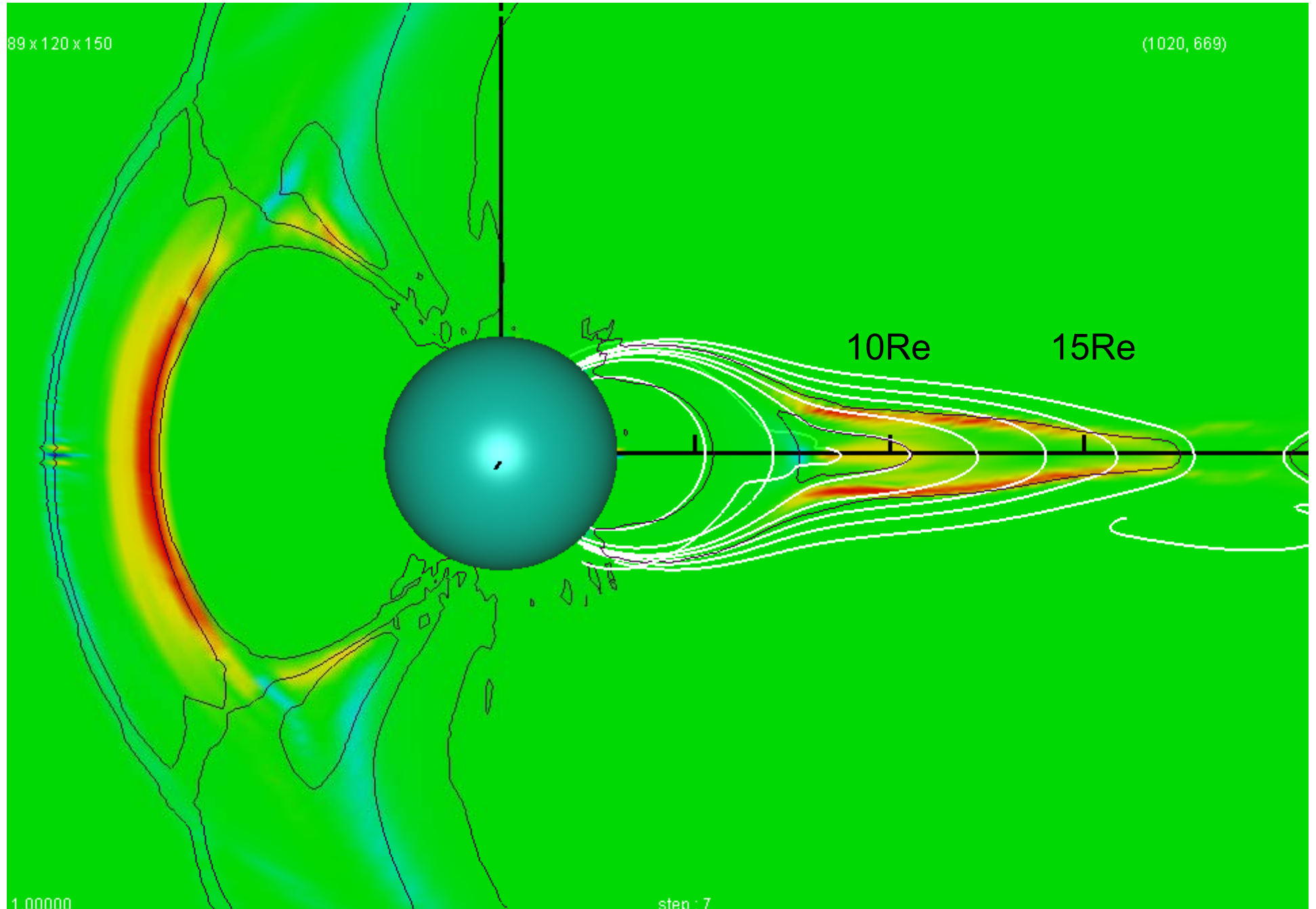
89 x 120 x 150

(1020, 669)



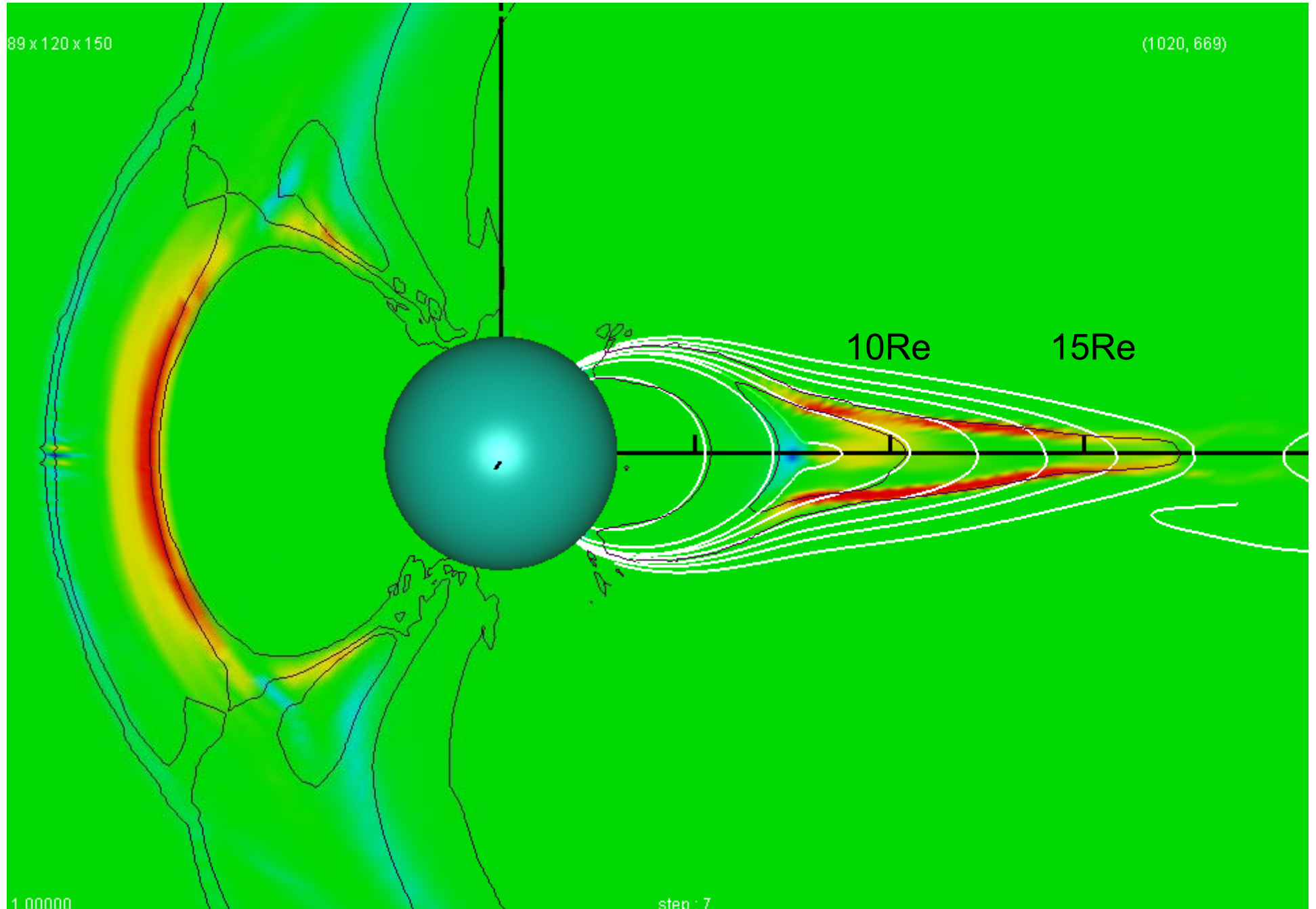
89 x 120 x 150

(1020, 669)



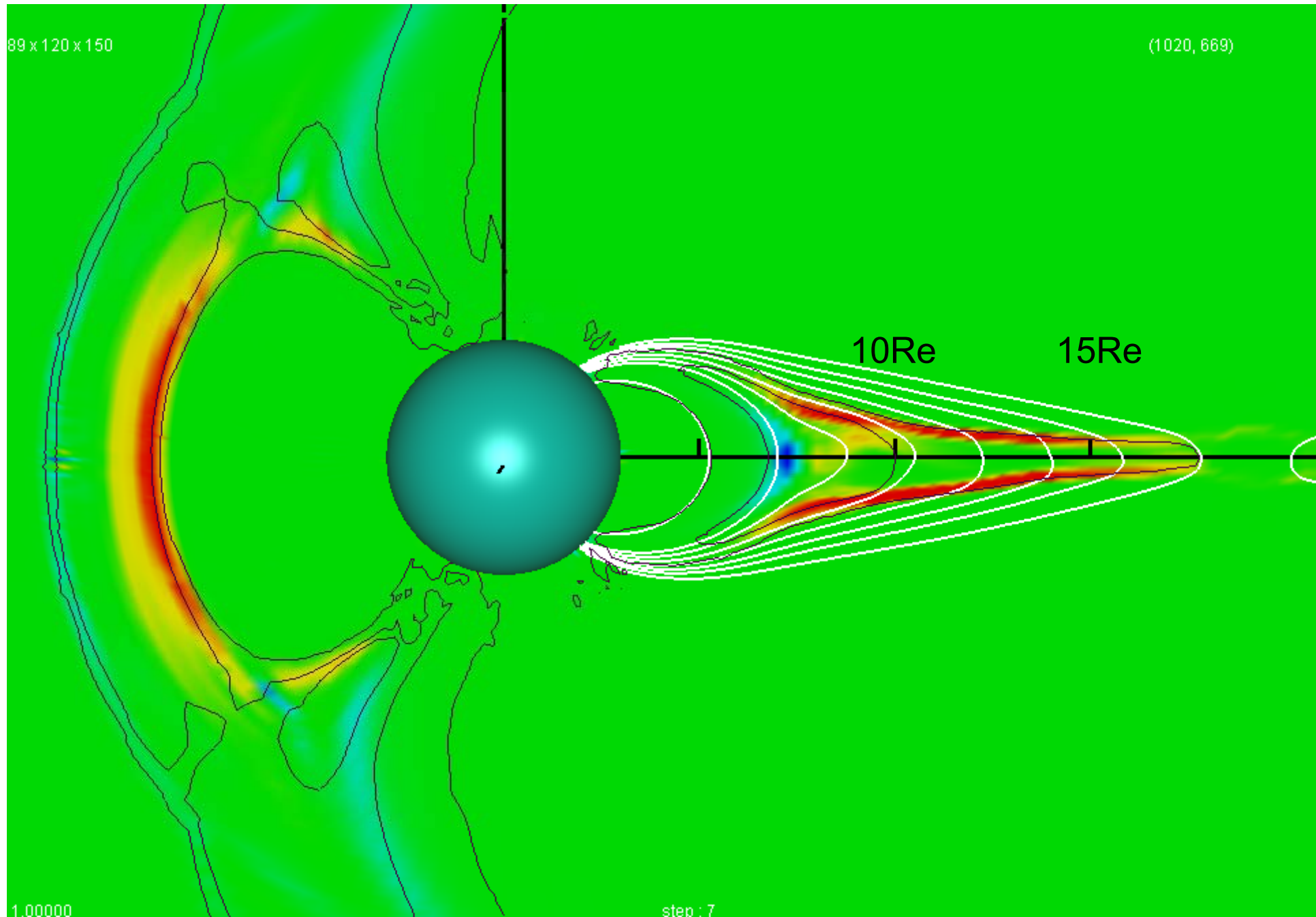
89 x 120 x 150

(1020, 669)



89 x 120 x 150

(1020, 669)

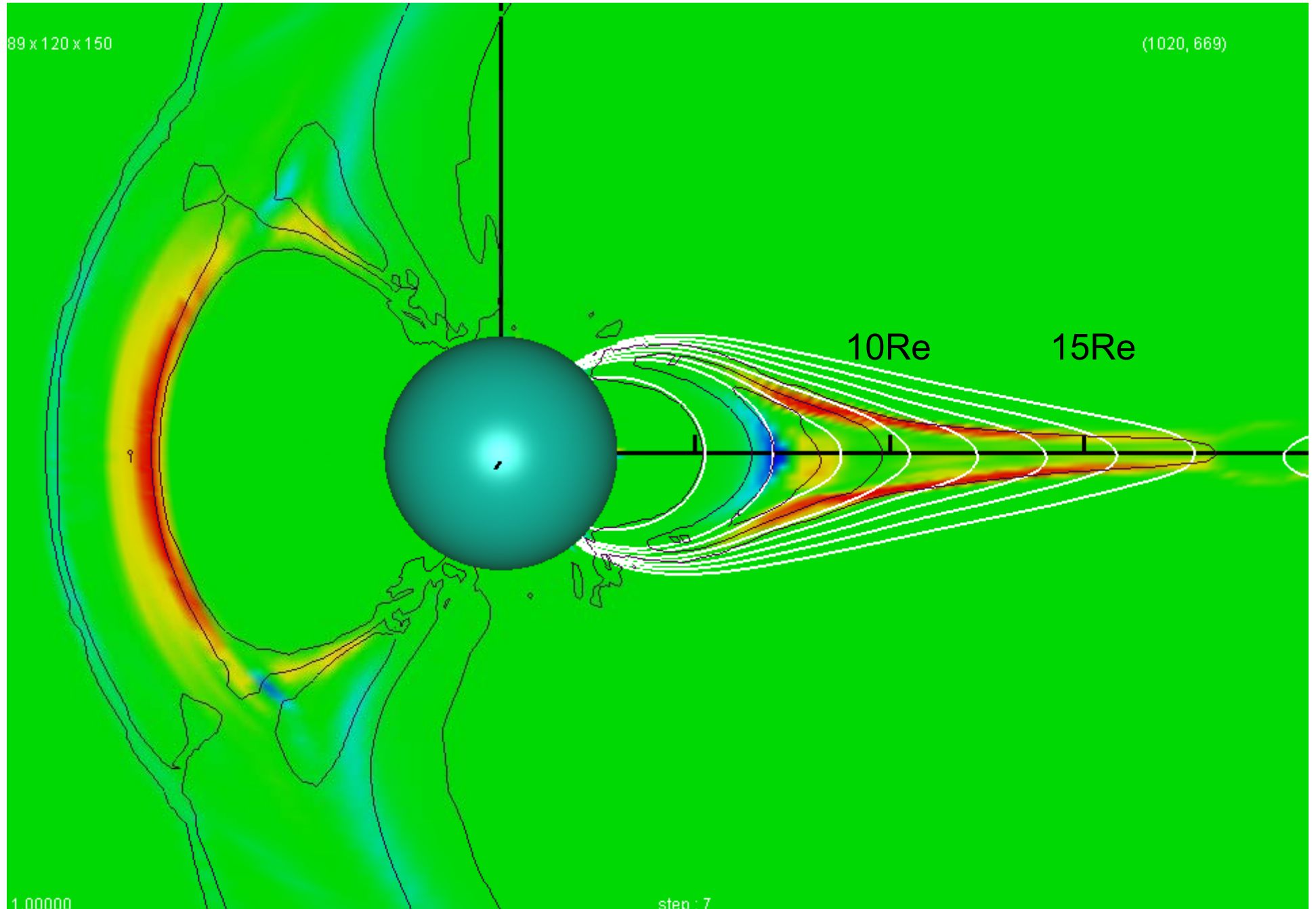


1.00000

step : 7

89 x 120 x 150

(1020, 669)

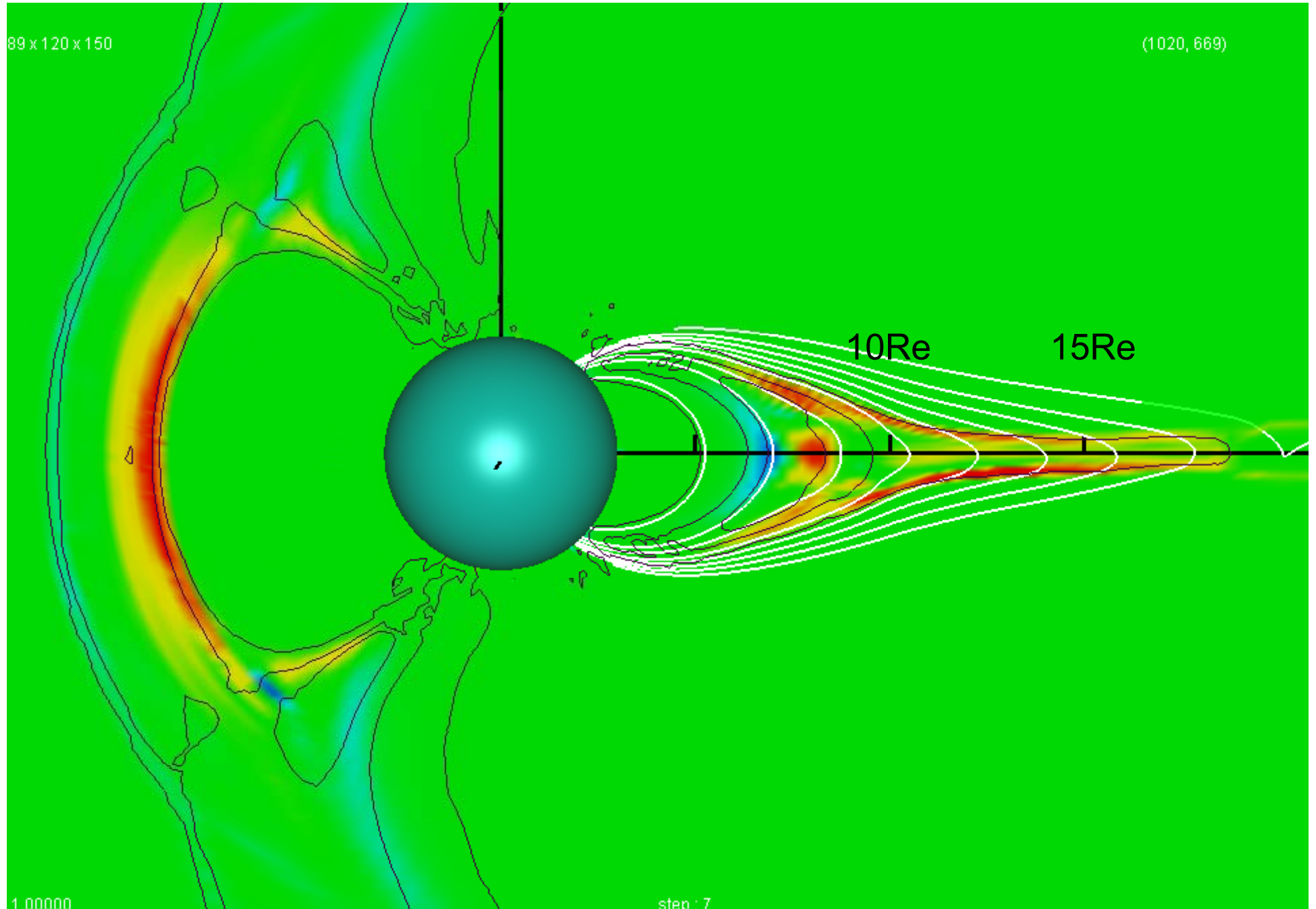


1.00000

step : 7

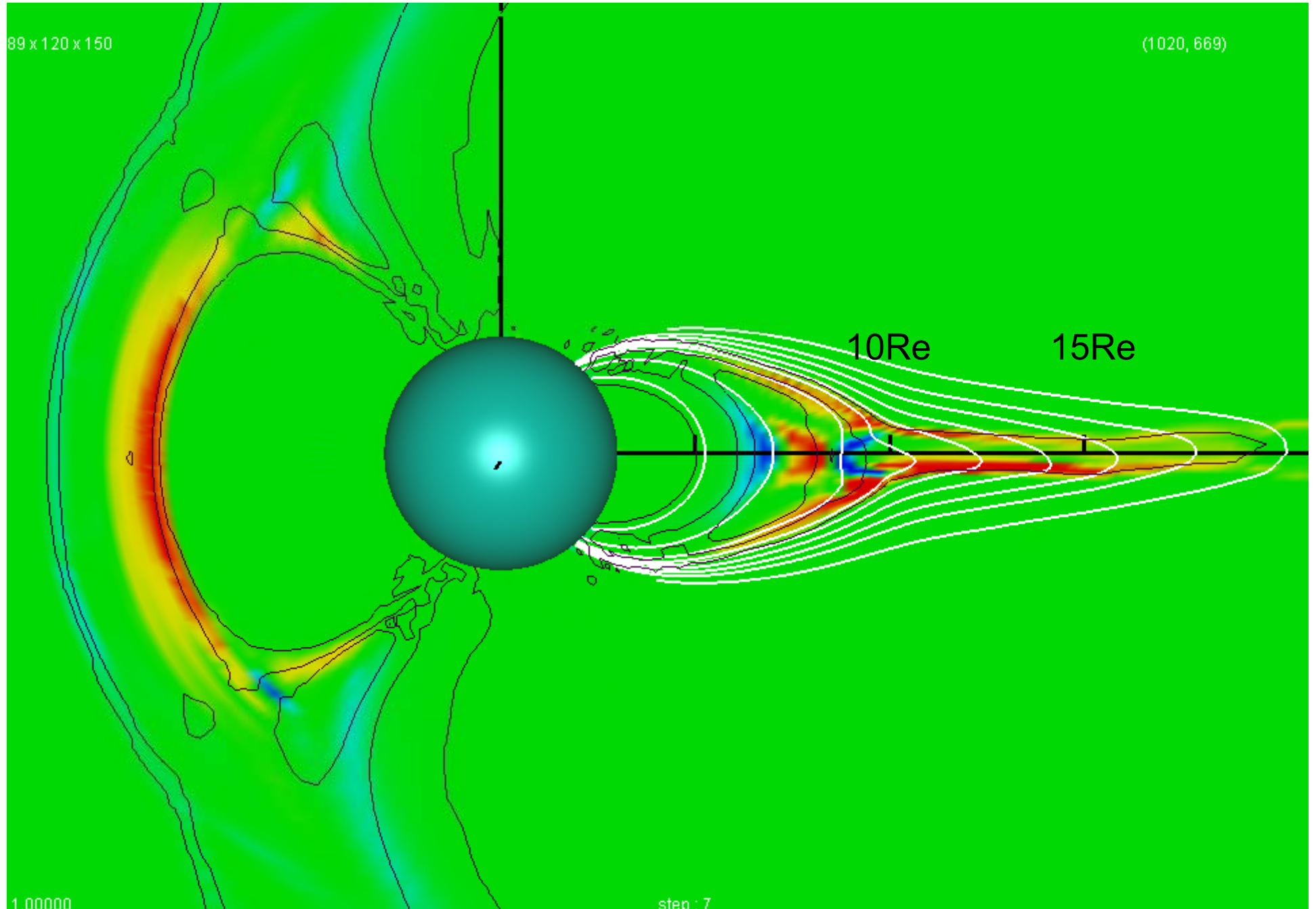
89 x 120 x 150

(1020, 669)



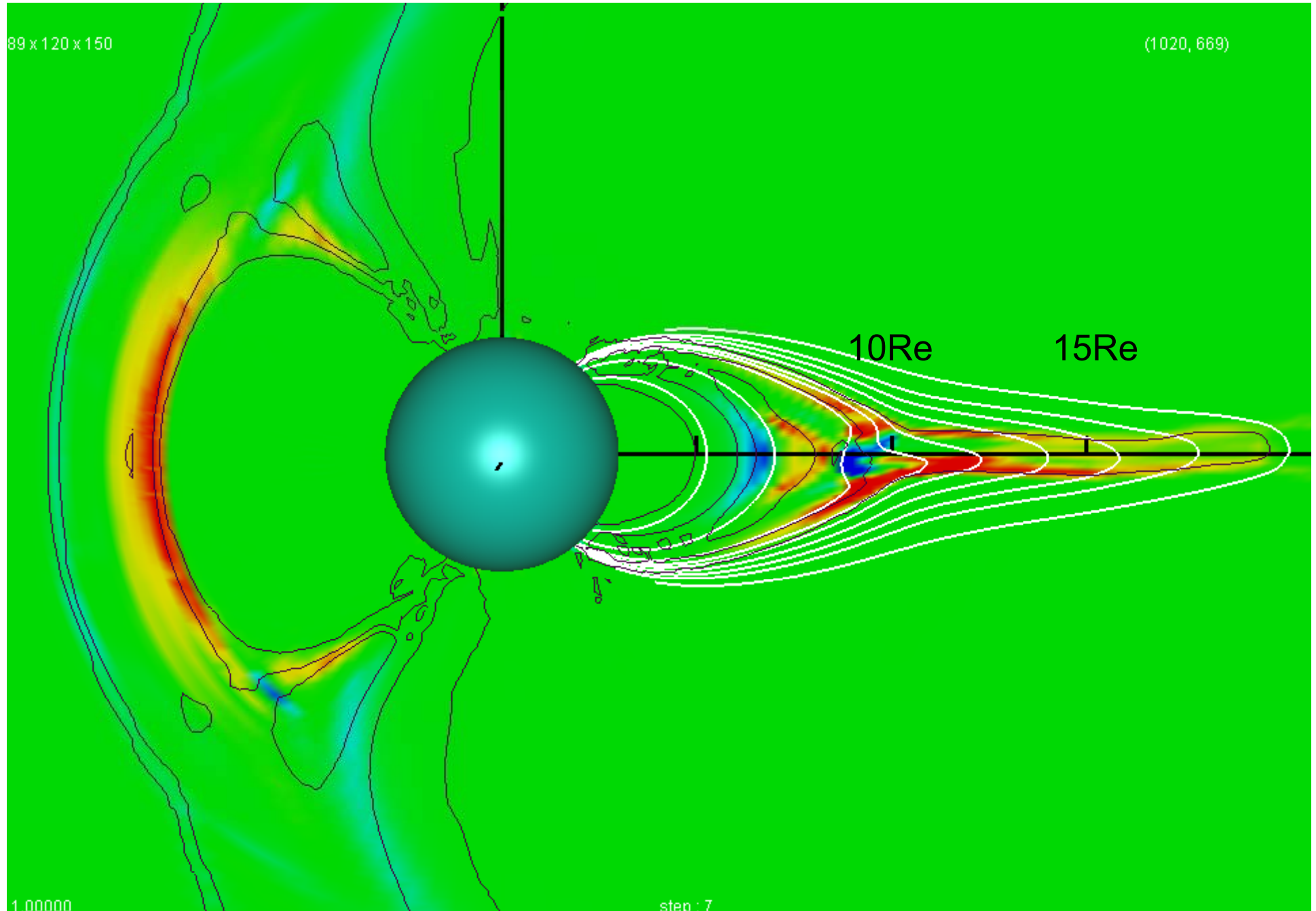
89 x 120 x 150

(1020, 669)



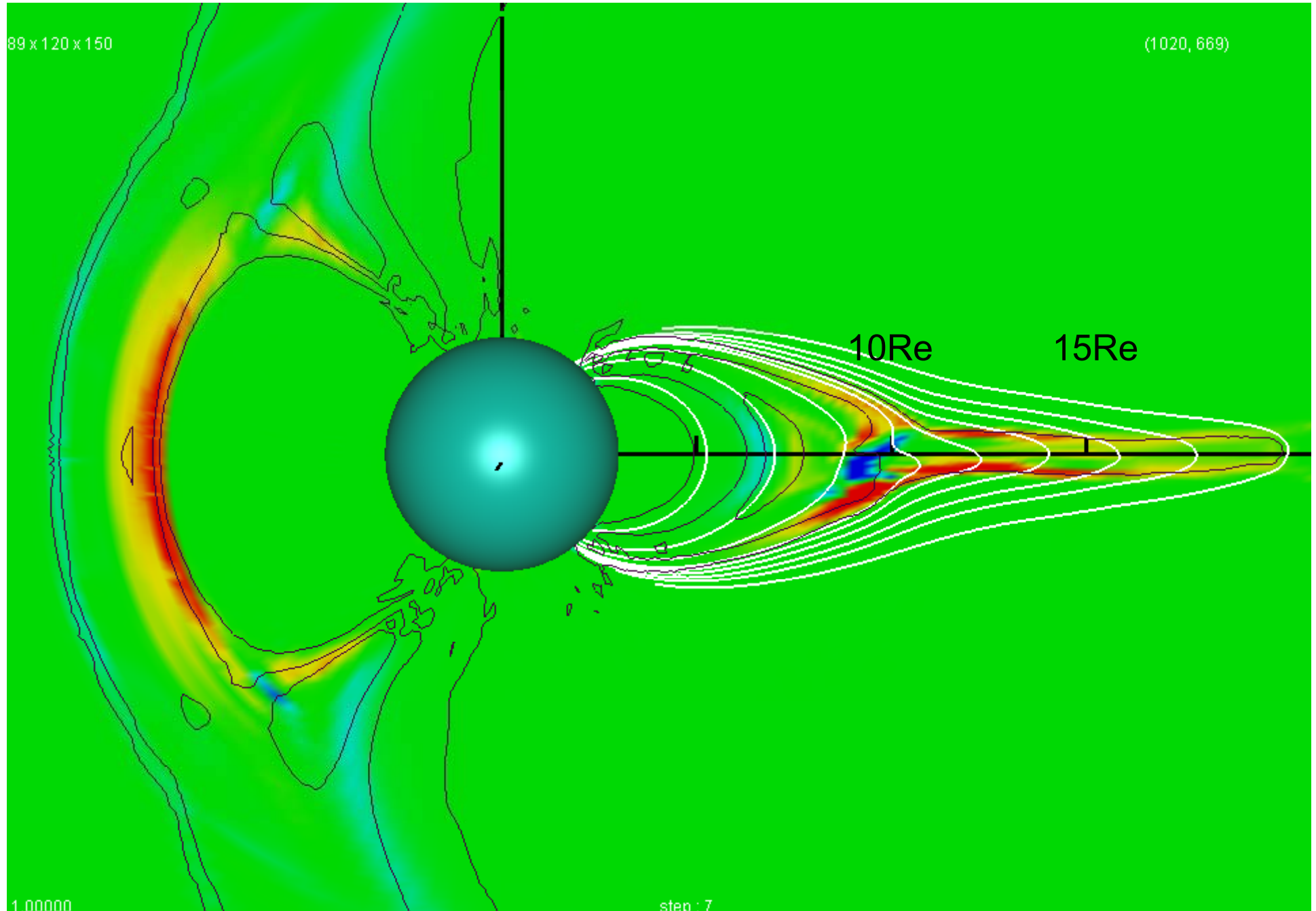
89 x 120 x 150

(1020, 669)



89 x 120 x 150

(1020, 669)



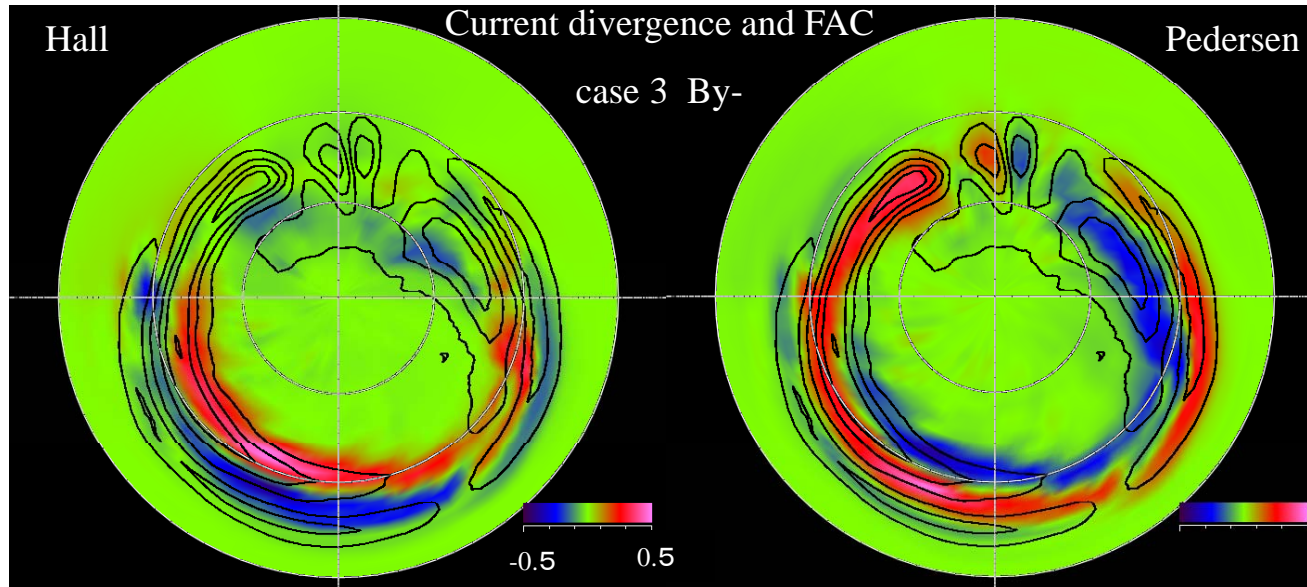
1.00000

step : 7

Jy end(10)

end

Cowling channel



$$\text{div} (J_{\text{Hall}}) + \text{div} (J_{\text{Pedersen}}) = J_{\parallel}$$

left

right

contour

