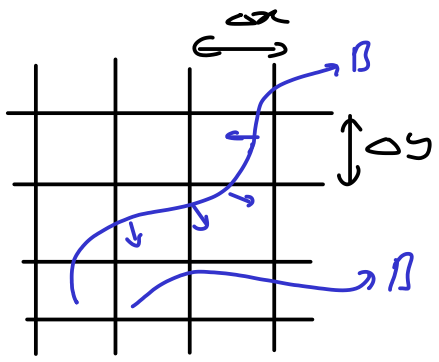
Field aligned coordinates

Contents

Non-aligned Coordinates



Changing B field, high β

→ difficult to align coordinates with B field

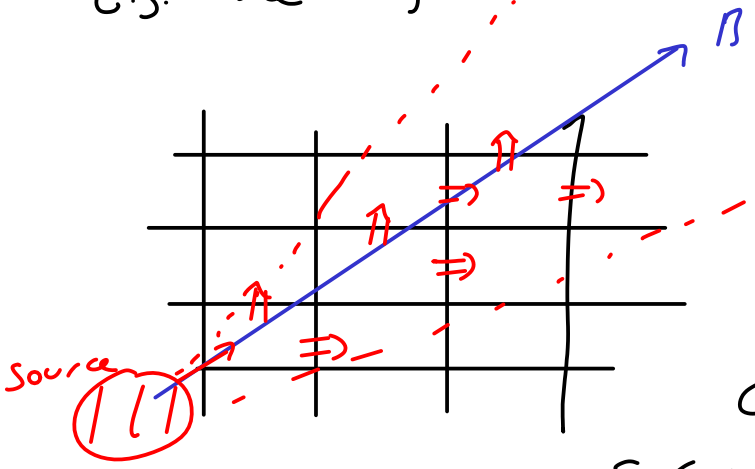
→ Don't align to field, but solve as accurately as possible non-aligned

Transport

$\parallel$ (parallel) ← Much larger than $\perp$

$\perp$ (perpendicular)

e.g. heat flux



Mix together parallel and perpendicular heat flux ("pollution")

Can be done accurately:

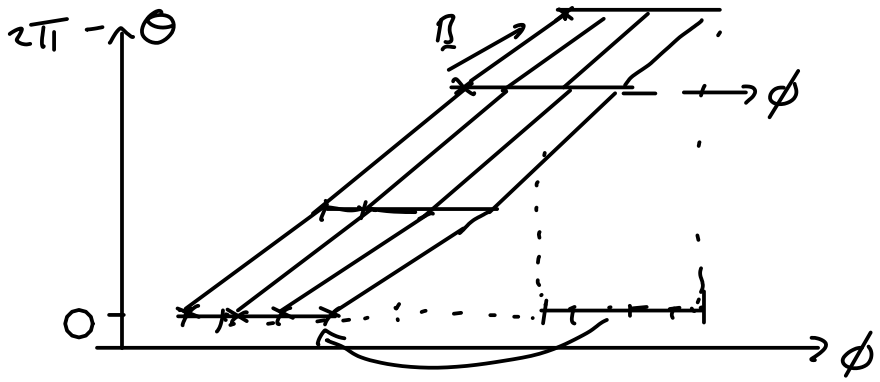
S. Günter et al. JCP 209 (2005) 354-370

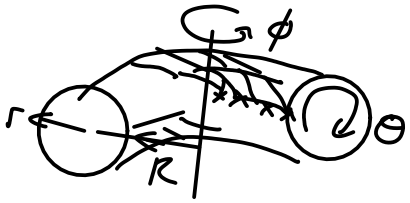
Field-aligned

By aligning a coordinate to the $\underline{B}$ field

- Transport $\parallel$ vs $\perp$ separated
- Different physics $\parallel, \perp$ e.g. drifts resolved
- Typically $k_\parallel \ll k_\perp$ $\Rightarrow$ can reduce resolution

flux tube Beer, Cowley, Hammett PoP 2, 2687 (1995)





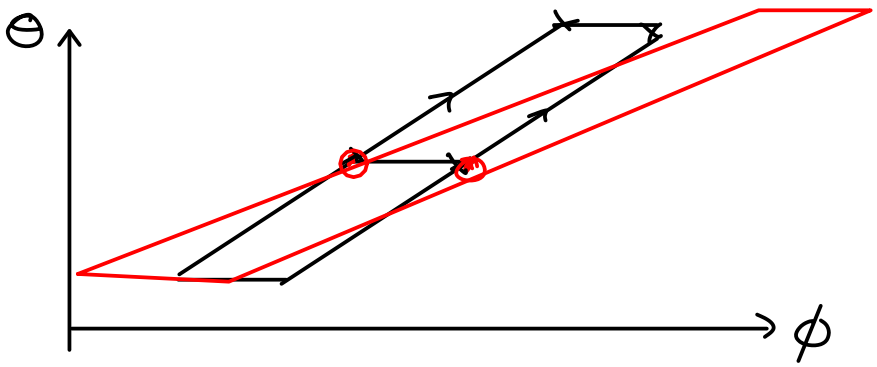
$$x = \psi \qquad y = \theta \qquad z = \phi - \int_{\theta_0}^{\theta} \frac{B_\phi r}{B_\theta R}\, d\theta$$

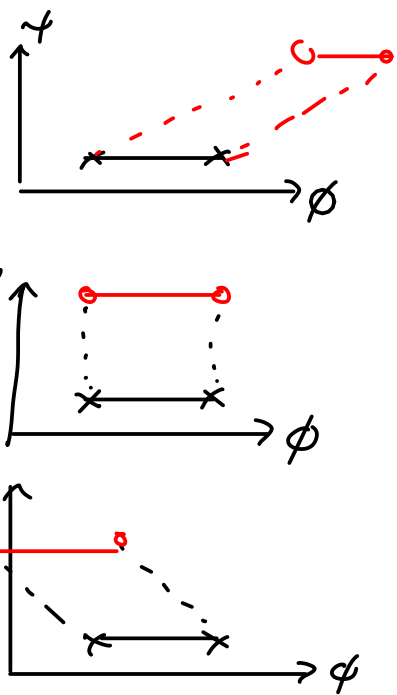
Periodicity

① Twist-shift periodic in ϕ

② Follow flux tube around multiple 2π
(like ballooning transform)

Radial coordinate



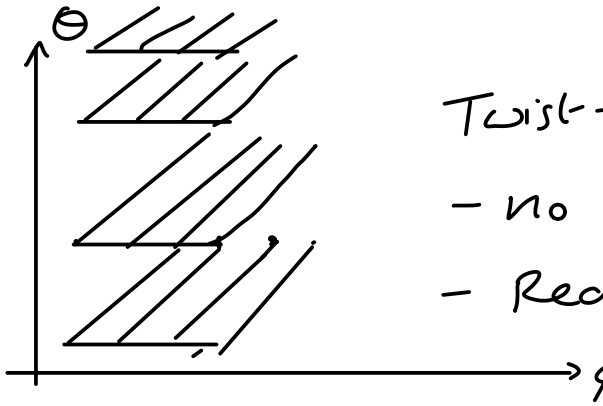


Matching of sheared grids

- Mixing of ϕ and ψ derivatives
- Special "matching" location where Twist-shift occurs.
- has a singularity at x-point $B_\theta \to 0$

Shifted Metric

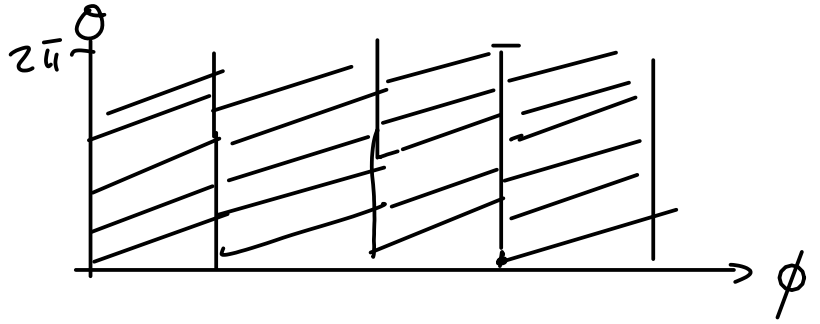
B. Scott PoP 8, 447 (2001)



Twist-shift on every θ point
- no special location
- Reduces distortion

Toroidal coordinates

$\theta \leftrightarrow \phi$

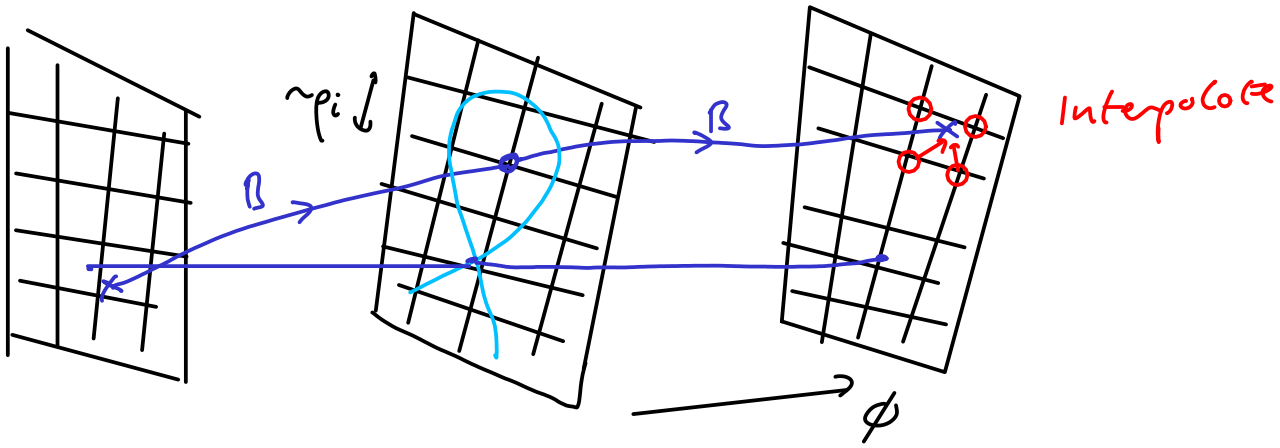


Closer to orthogonal
- usually more accurate
- needs to be high resolution in θ

Metric tensor varies in θ
- harder/impossible to use FFT methods

Flux Coordinate Independent (FCI)

Calculate derivatives along magnetic field lines by tracing the magnetic field and interpolating.



F. Hariri, M. Ottaviani Comp. Phys. Comm. 184 (2013) 2419 - 2429

A. Stegmeir

See: FENICIA, GRILLIX, (BOUT++)