The case for QUASAR (NCSX)

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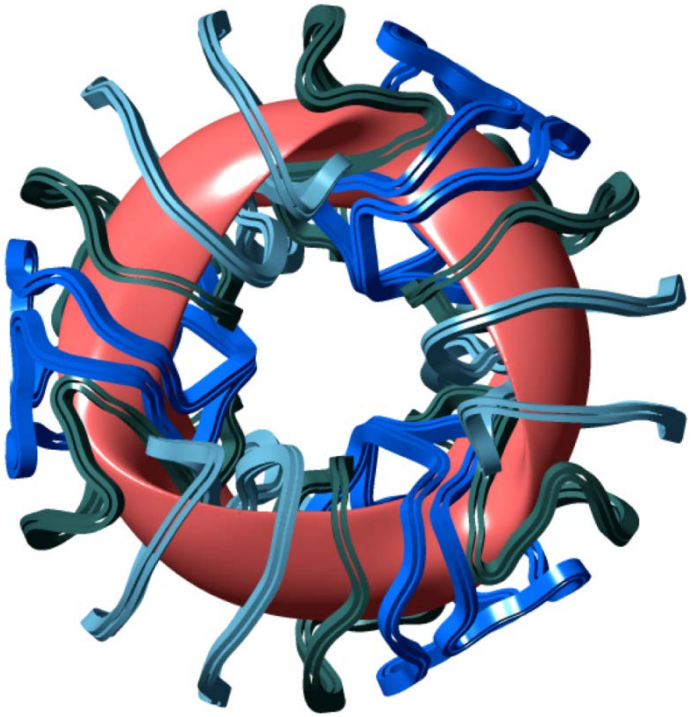


My starting point

I 

Tokamaks

Then why support QUASAR?

- **Tokamaks have many advantages**
  - Yada, yada, yada
- **Tokamaks have challenges**
  - Steady state
  - Disruptions
  - PMI (Everybody's problem)
- **A standard tokamak does not scale to a reactor!!**
  - Standard = $P_E, P_W, B_{\max}, \beta_N, q_*, profiles$
  - Needs too much current ***I***

Possible solutions

- Advanced tokamak physics
- High field
- High power output
- **Stellarators**

Stellarators

- Stellarators are inherently steady state
- Low or no current makes them disruption resistant
- Good plasma performance

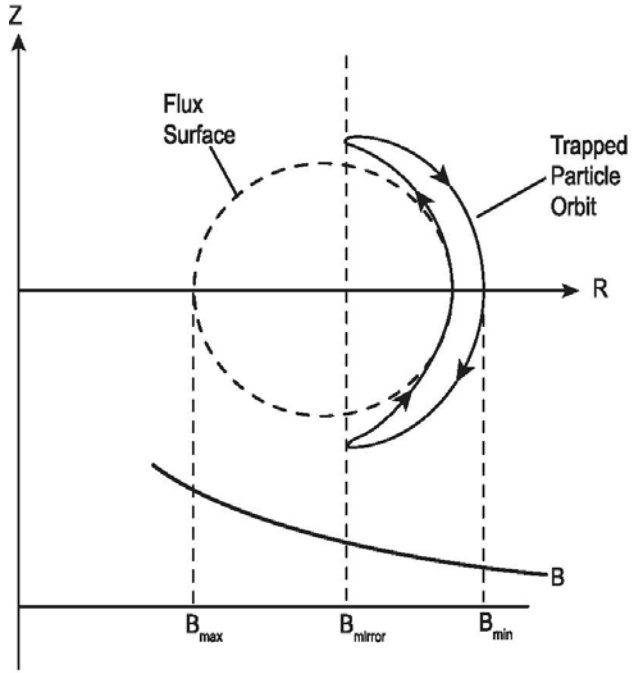
Why then hasn't the stellarator overtaken the tokamak?

Stellarator Challenges

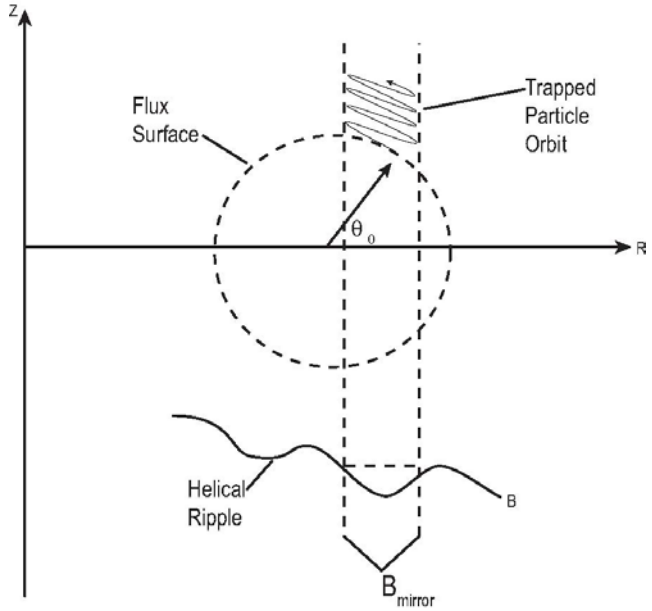
- Collisionless transport (Physics issue)
- Complicated magnets (Cost issue)
- Large size reactors (Cost issue)

Collisionless transport

Tokamak vs. stellarator neoclassical transport



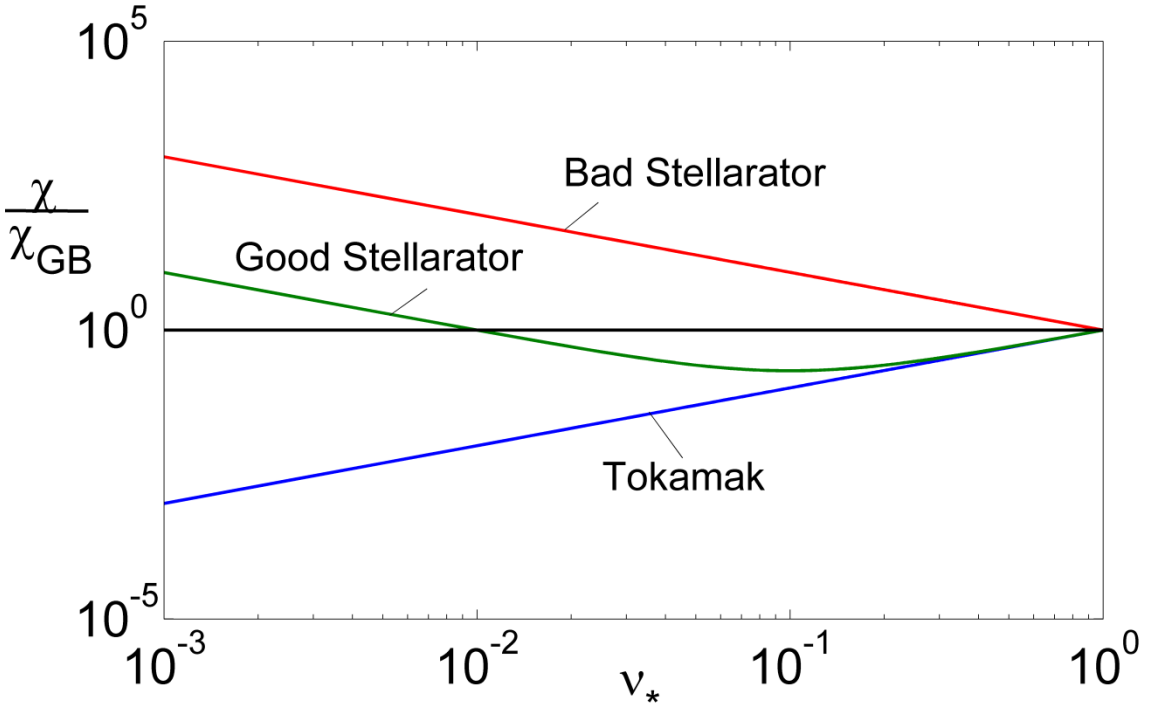
Tokamak



Stellarator

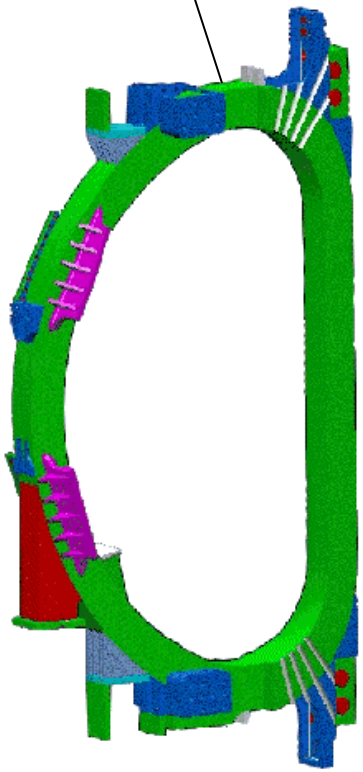
Solution – No $\|$ helical ripples

- Quasi-omnigenous stellarator (2 possibilities)
  - Quasi-isodynamic (W7-X)
  - Quasi-axisymmetric (QUASAR)



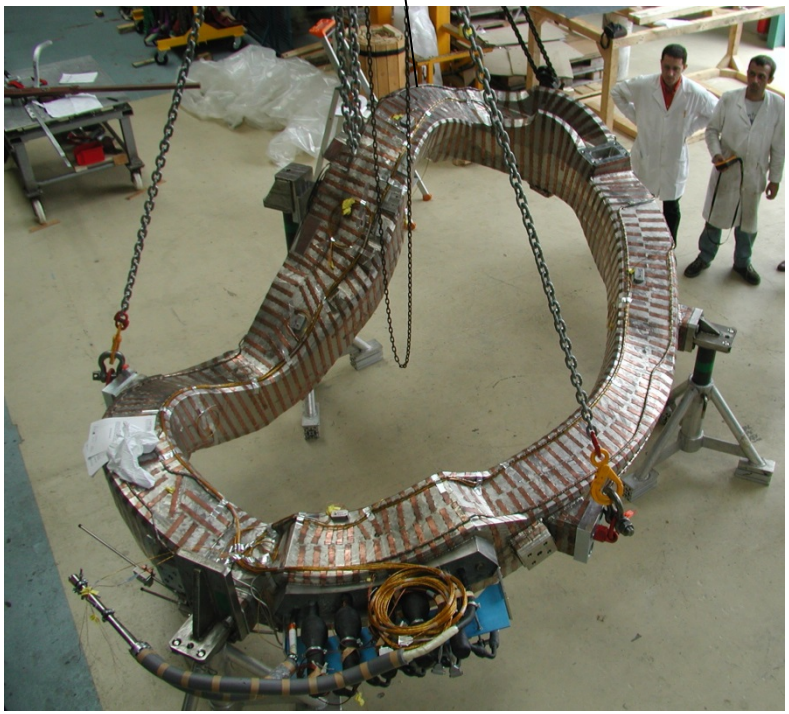
The Magnets

Walmart



Tokamak

Neiman-Marcus



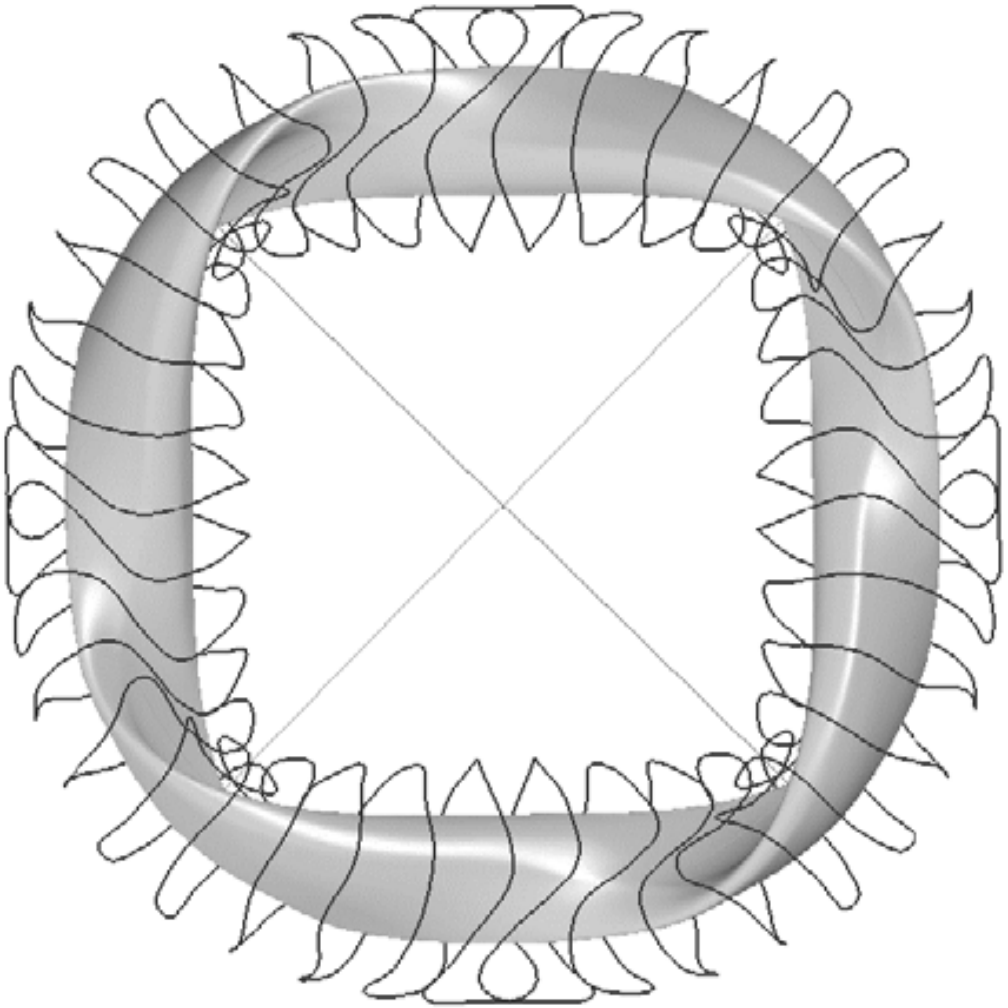
Stellarator

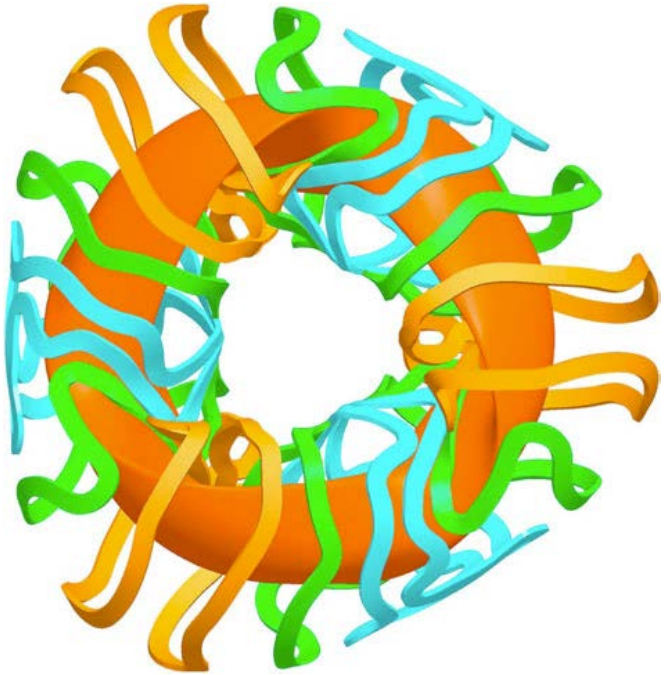
The Solution

- Expensive learning curve
- Experience
- The price has been largely paid

Large Size

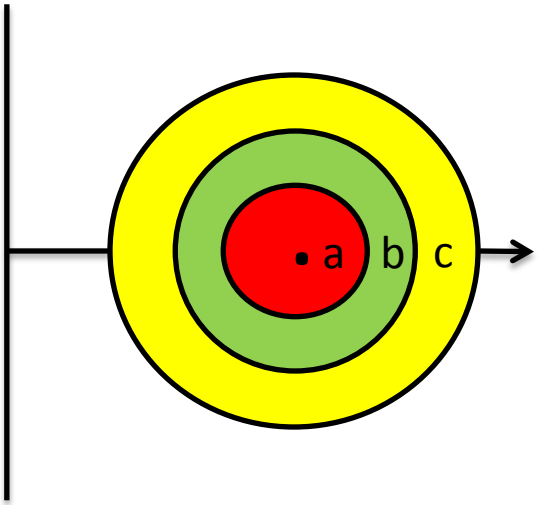
Compare HELIAS (W7-X) with ARIES-CS (QUASAR)





Scaling Relation

	HELIAS	ARIES-CS
$R_0(m)$	18	7.75
$a(m)$	2	1.7
$P_W(MW/m^2)_{max}$	1.7	5.4



Scaling

$$P_W A = P_n$$

$$\frac{Cost}{Watt} \propto \frac{V_l}{P_E} \propto \frac{1}{P_W}$$

Why not wait for W7-X?

- A car is a car is a car – right?

- A stellarator is a stellarator is a stellarator – right?
- Both W7-X and QUASAR are stellarators
- But they are very, very different stellarators

OK – Why QUASAR?

Short term:

- Theory says both W7-X and QUASAR should work
- A good start, but
- **We need experimental proof!!**
- W7-X is nearly completed
- QUASAR is already designed and partially constructed

Long term:

- QUASAR – the more economical path forward

Suggestions for FESAC to DoE

- Stop shutting down experiments
- Start building experiments
- Make QUASAR part of the 10 year plan
- Sooner rather than later

Putting our money where our mouth is

If QUASAR is built MIT would partner with PPPL:

- Engineering
- Diagnostic development
- RF heating development
- Major part of scientific team

My new MHD book