The Quasi-Omnigeneous Stellarator (QOS) Project at ORNL

Presentation to Dr. Anne Davies

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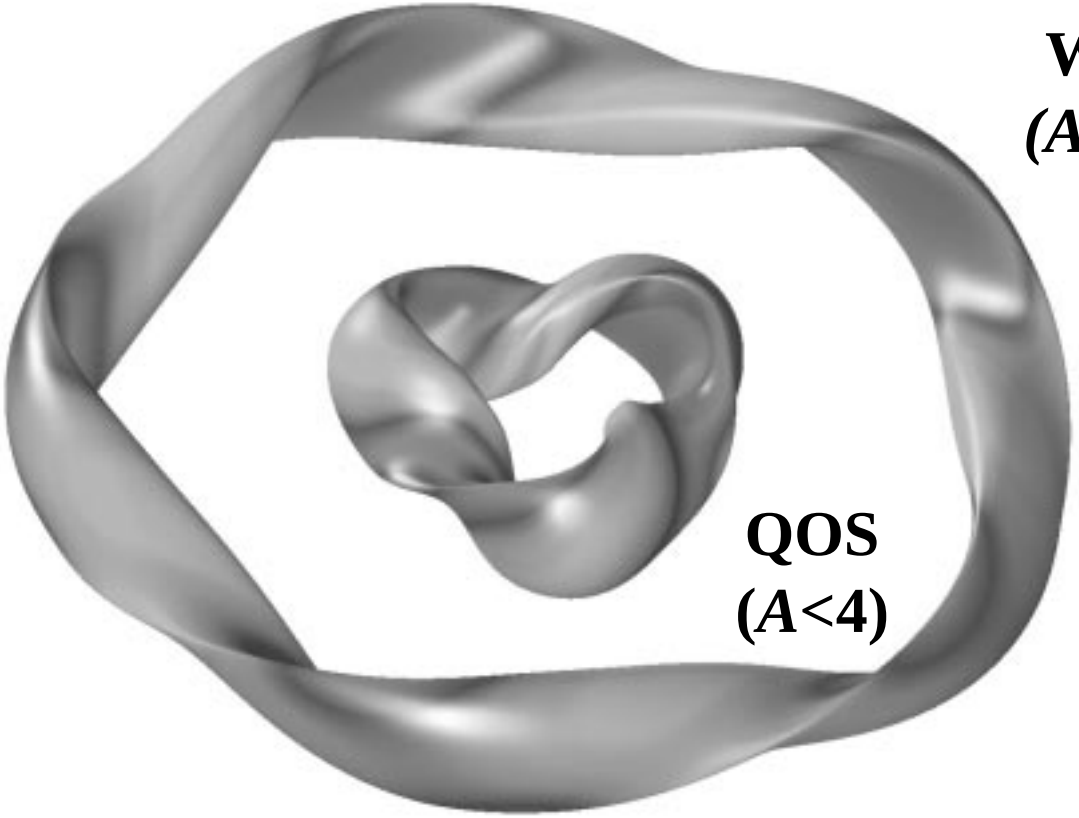
Stellarators are attractive

- **Limit ripple losses**
  - **tunnel through "Mt. Ripple"**
- **Solve disruption problem inherent to tokamaks**
  - **control resonances (external transform)**
  - **avoid *q*=2 surface in plasma**
  - **control external kinks**
    - **QAS via shear**
    - **QOS via reduced plasma current, shear**

QOS Stellarators can be made compact (low $A = R/a$)

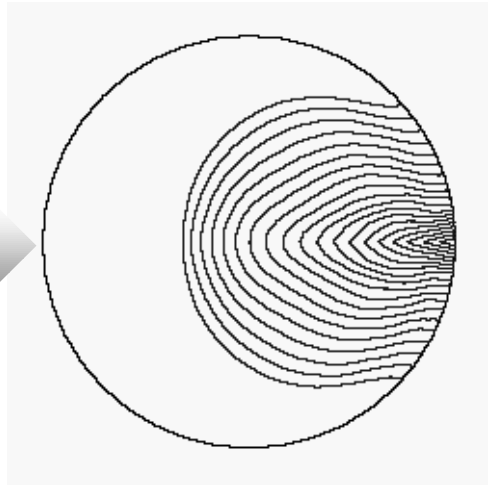
SAME minor radius *a*

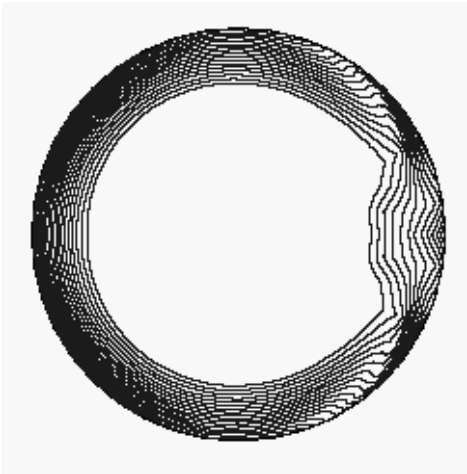


What is *Quasi-Omnigeneity*?

Drift orbits for fixed pitch, ε/μ

Plasma boundary





Unoptimized

Drift optimized

Drift trajectories *aligned* with flux surfaces: long time orbit confinement

QOS minimizes neoclassical *ripple losses*

- **Access at low *A* to high *T*, low ν**
  - **on bounce average, orbits are confined to flux surfaces**
- **No underlying symmetry required**
  - **contrast with QAS, QHS**
  - **flexibility to control plasma current**

QOS shows exciting possibilities

- **Disruption avoidance and mitigation**
- **Low recirculating power**
- **Compact design ($A = R/a < 4$)**
- **PoP, reactor-sized QOS**
  - **Mercier, ballooning, kink stable to β=7%**
- **QOS reactor (R<10m)**
  - **prompt alpha losses < 10%**

Quasi-Omnigeneous Stellarator

- Major Radius 1.0 m
- Plasma Radius 28 cm
- Aspect Ratio 3.6
- Plasma Volume 1.55 m^3
- Magnetic Field 1 T
- Plasma Current <150 kA
- Pulse length 0.2 - 1 s
- 0.4 MW 53/60 GHz ECH
- 1 MW 6-20 MHz ICRF

- **ORNL - UT-Austin partnership; PPPL collaborator**
- **6.5 M$ total project cost, 2.5M$/year budget**

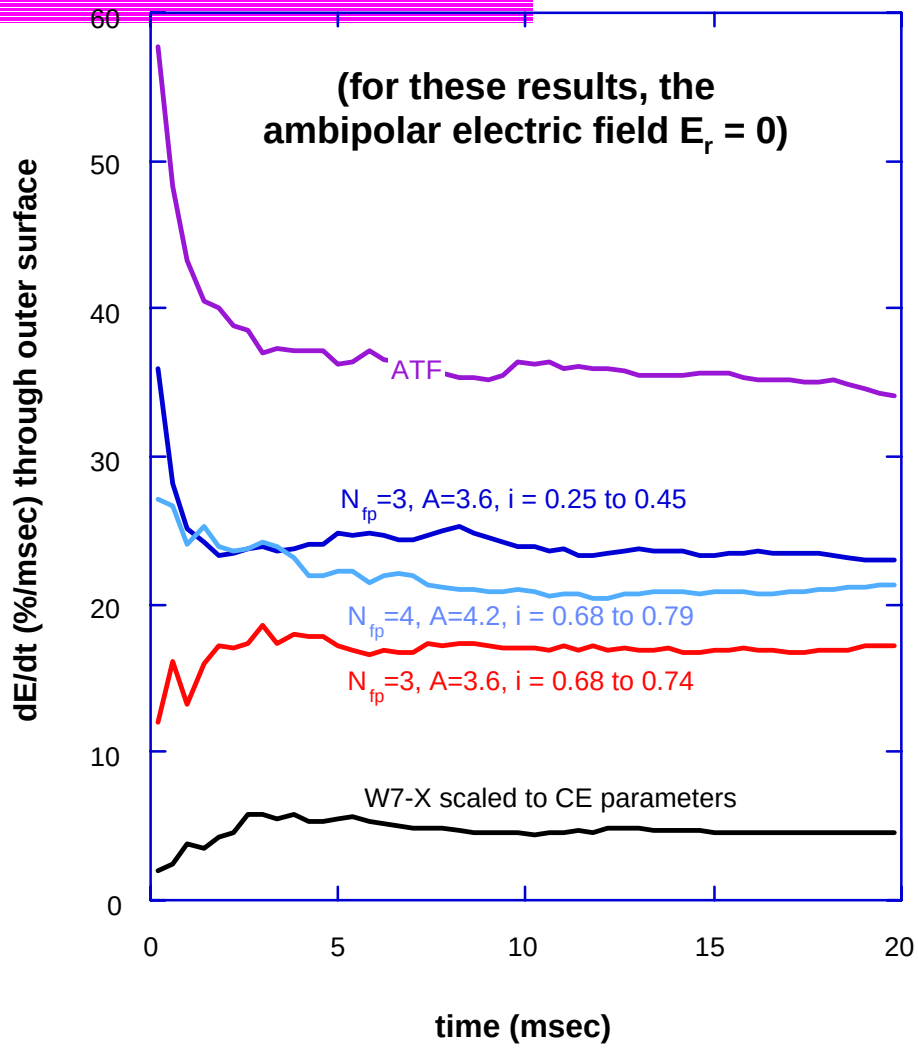
ORNL QOS Concept Exploration (CE) Experiment

- **Compact QOS at ORNL**
  - **low cost (<$6.5M), low β (<2%)**
  - **unique (first) QO experiment**
- **Test QO confinement improvement**
  - **access low ν regime possible**
- **Investigate hybrid (current) effects**
  - **flexible: range of stability, kink, transport, equilibria via external coils**
  - **support QA/QO PoP goals**

Present Status of QOS

- **Preliminary physics design for QOS**
  - **3 < *A* < 4.0 (*N*=3,4); *a* = 0.3m, *B* = 1T**
  - **drift orbit confinement allows heating to access low-collisionality regime with available power (perp. ICRF heating)**
  - **nc energy confinement time (no E_r): 8-9 ms, 2 X ATF (same *a*, *A* = 8)**
  - **anomalous (ISS95) energy loss rate is 6X neoclassical (dominant loss)**

Monte Carlo Energy Losses



Present Status (cont'd)

- **Coil design**
  - **lower *N* => lower *A* for fixed ripple**
  - **exploring *N*=3 (*A*=3) and *N*=4(*A*=4) designs**
  - **composite fiber forms being considered for low cost coil fabrication**

QOS Project Summary

- **Partnering with UT-Austin underway**
  - **Joint project, program development**
- **Physics design of a low aspect ratio, CE-sized device near completion**
- **Innovative composite fiber forms**
  - **under consideration for economical coil fabrication**