Turbulent Transport in Stellarators

Turbulent energy transport is dominant in most LHD discharges.
also true in highest confinement W7-AS discharges.
expect weak helical-neoclassical energy transport in NCSX.

Turbulent transport prevents impurity accumulation (Talmadge)
in edge and SOL of LHD and W7-AS at high density.
Neoclassical impurity transport predicts accumulation.

Dominant transport process is not well characterized,
basic processes are not identified.
How can stellarator designs be properly optimized??

Limited capability for computational simulation is now in hand.
averaging several flux-tube domains is adequate??
should develop a code with full-surface (or annulus) domain?

Neoclassical transport with quasi-symmetry

Standard neoclassical transport codes employ collision operators that do not conserve momentum, and that assume bulk flows are negligible.

As in axisymmetric systems, this leads to incorrect predictions for quasi-symmetric configurations. Correction procedures have been developed, and are implemented in `PENTA` (D. Spong).

Ambipolar radial electric field, as well as transport of particles, heat and momentum can be estimated by `PENTA` .

Optimization of quasi-symmetric configurations minimizes the effective ripple, but eventually further reductions are pointless.

Other properties that affect turbulence may be more important;
maximizing zonal flows, for example, may be paramount.
need to understand both to make intelligent trade-offs.

Validation of stellarator transport theory

Standard neoclassical theory (applicable to LHD and W7-AS) is thought to be mature, and is consistent with *high temperature* data from the core of W7-AS.

Application of `PENTA` to analysis of HSX experiments will provide an indication of the role of turbulent transport in HSX, and may permit validation (when anomalous transport is small).

Present stellarator-capable turbulence codes with flux-tube domains should be used to analyze LHD and W7-AS data.

Further theoretical and computational work should address the question of whether flux-tube codes are too simplified.
In particular, are large-scale zonal flows well represented in simulations that 'know about' only a small part of a flux surface?

Develop validated transport theory for design optimization.