COILOPT Advances: An Alternative to ONSET

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TOPICS

- Surface generation.
- COILOPT context relative to ONSET.
- Examples of COILOPT optimizations.
- Summary/Plans.

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ACKNOWLEDGEMENTS

Discussions with John Whitson (who with Steve Hirshman wrote the original version of the present code), Art Brooks, and Prashant Valenju have greatly benefited this effort.

A NEW SURFACE GENERATION TOOL HAS BEEN DEVELOPED

- "Winding surfaces" are central to coil design.
- COILOPT contained the pieces needed to generate surfaces at particular plasma-coil distances.
- A surface optimization code, "SURFOPT" was developed.
- This technique offers some advantages over analysis-based algorithms (cf work by Art Brooks).

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SURFACES WITH A RELATIVELY FEW HARMONICS (66 IS TYPICAL) AND SMALL DISTANCE ERRORS HAVE BEEN GENERATED FOR THE R ~ 1.5 m C82

d_tgt (cm)	dmin (cm)	dmax (cm)	rms_er (mm)	grid UxV
18	17.95	18.07	0.1	205x73
18	17.95	18.07	0.1	205x200
28	27.92	28.14	0.17	205x73
38	37.82	30.36	0.43	205x73
50	48.8	53.4	2.4	205x73

Distances for the 50 cm surface sometimes required good initial guesses for the u-v location on winding surface.

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COILOPT IS A RELATIVELY EFFICIENT, FLEXIBLE TOOL FOR DESIGNING STELLARATOR COILS

- **Coils are parameterized with representations appropriate for the type of coil.**
- **Physics and engineering parameters are calculated, and errors minimized within a Levenberg-Marquardt optimizer.**
- **Targets include, field errors, resonant error, coil length, plasma-coil spacing, and geometric extent.**
- **Coils may be constrained to fixed surfaces with the option of optimizing the constraining surface.**
- **Coil optimization remains an art.**

Compared to ONSET, COILOPT is better understood, more flexible, and has the likelihood of faster execution.

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COILOPT BEEN IMPROVED TO ADDRESS PRESENT SOME OF THE PRESENT COIL DESIGN ISSUES

- Use of Fortran 90 objects to represent modular coils.
- Multiple winding surfaces.
- Saddle coils in addition to circular VF, helical, and modular coils.
- B_{norm} from equilibrium may now be included in field target.
- Faster execution time through utilization of symmetries.

Additional needed improvements will be discussed at the end of this talk.

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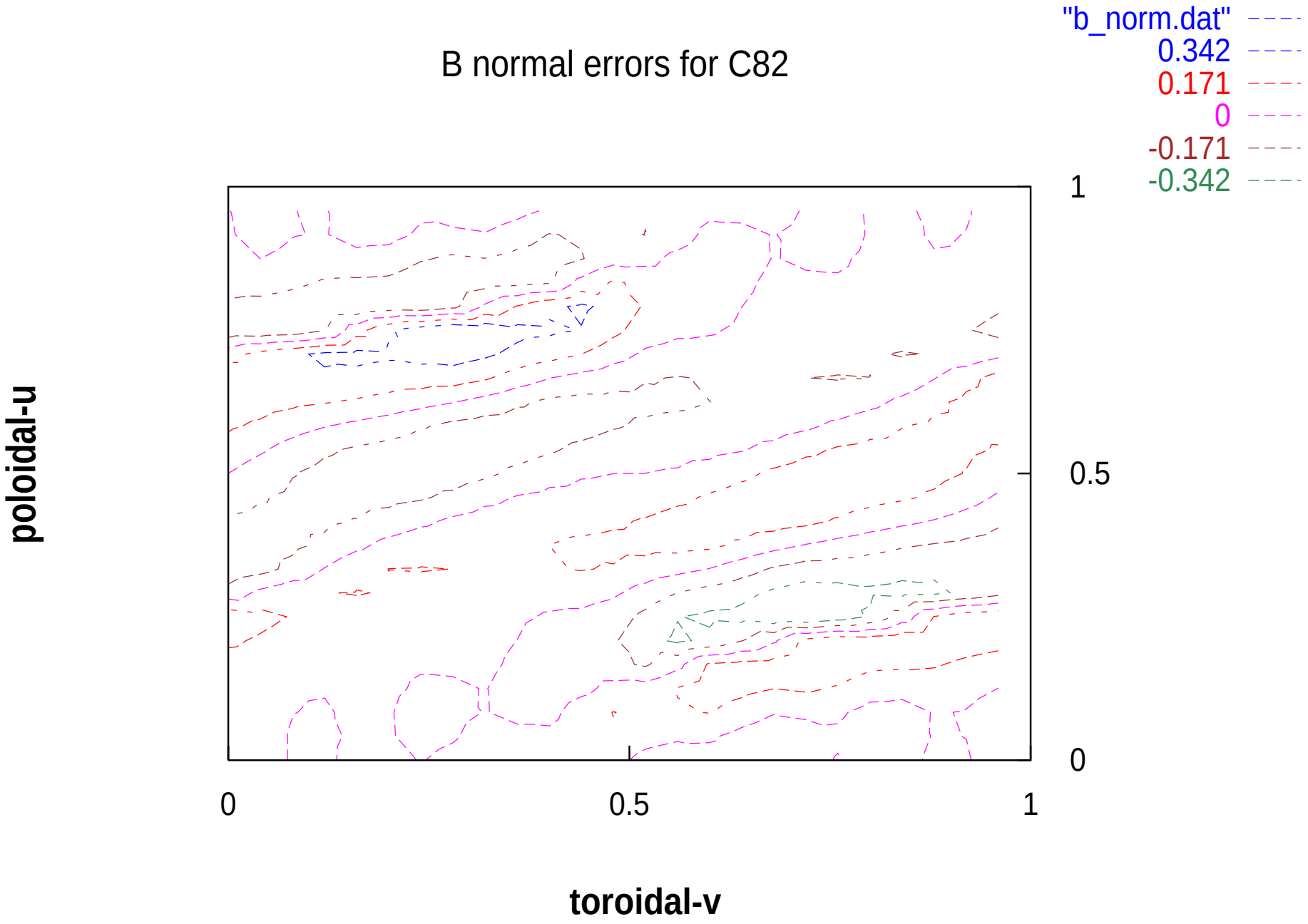
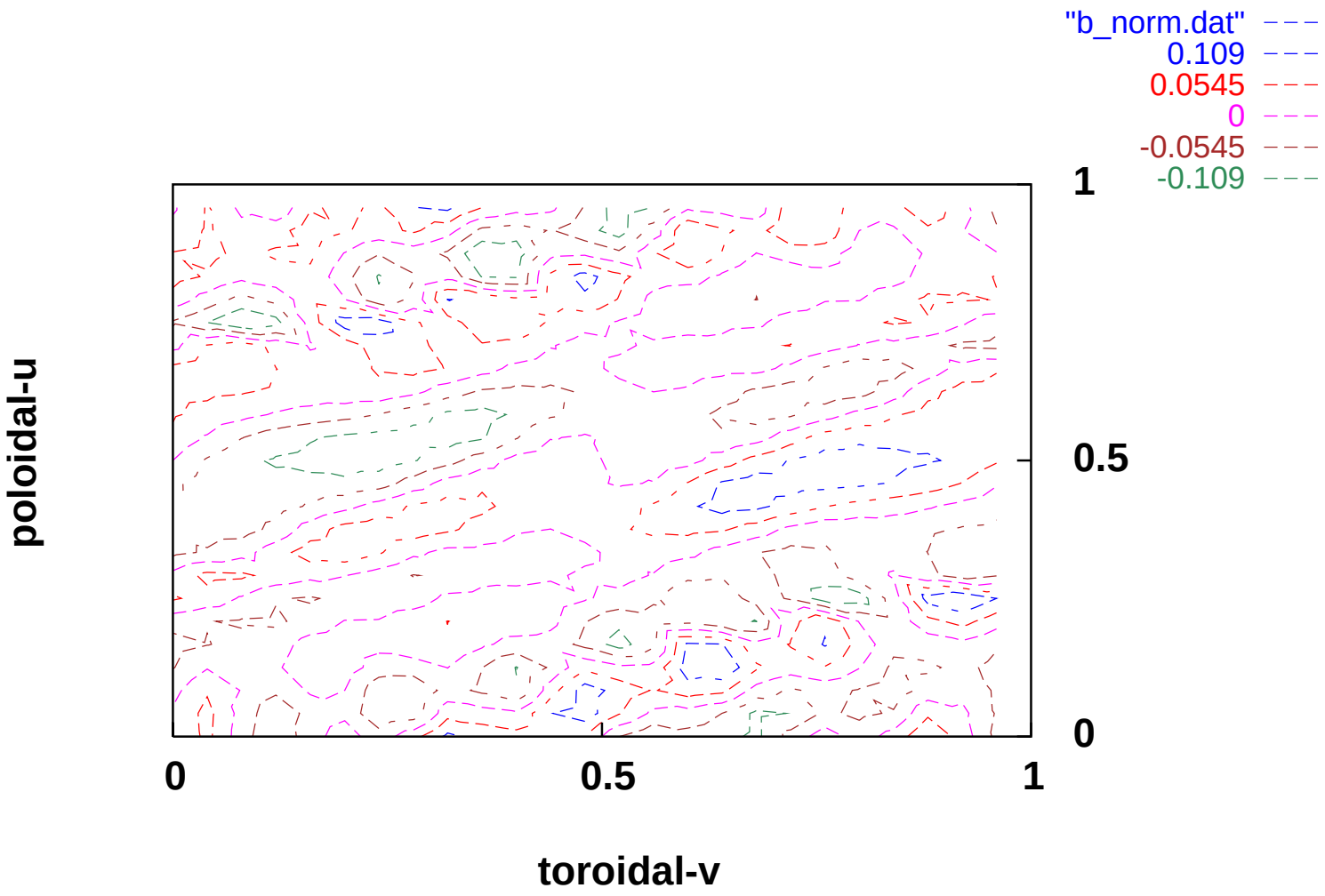
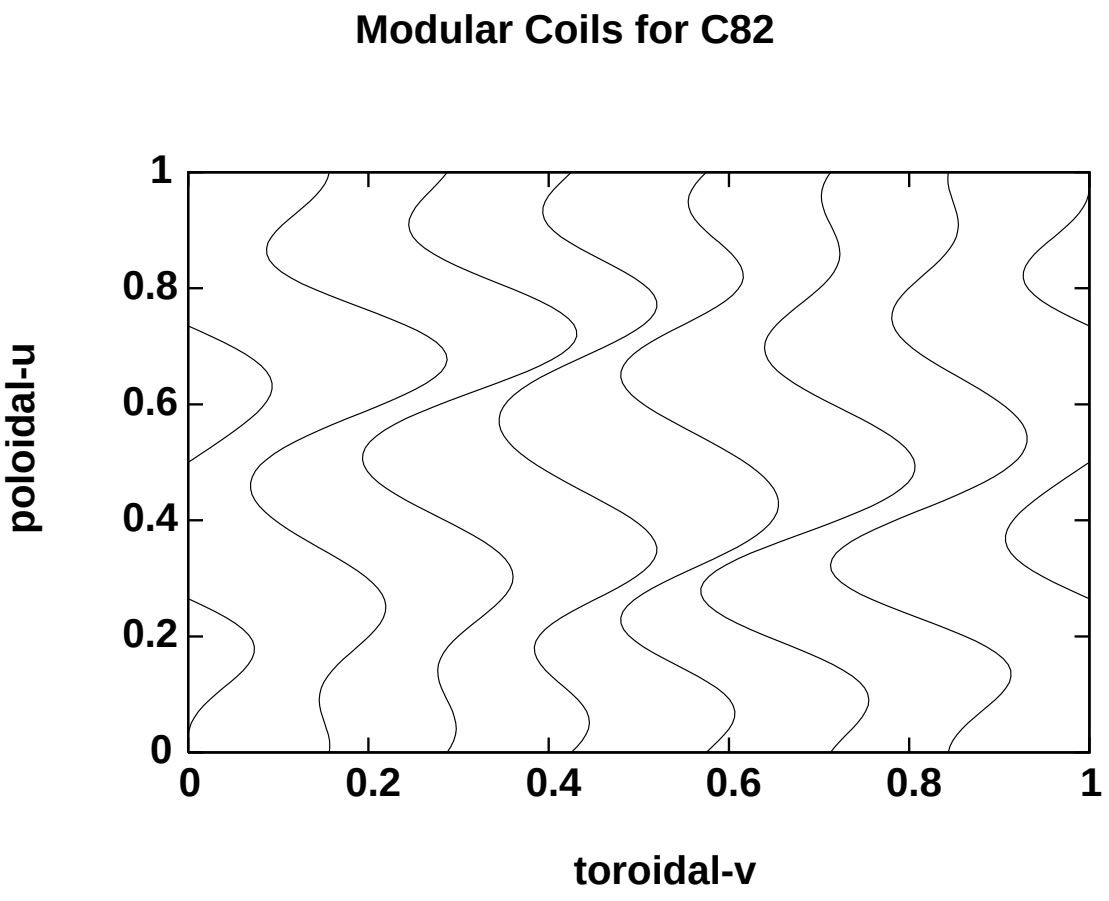
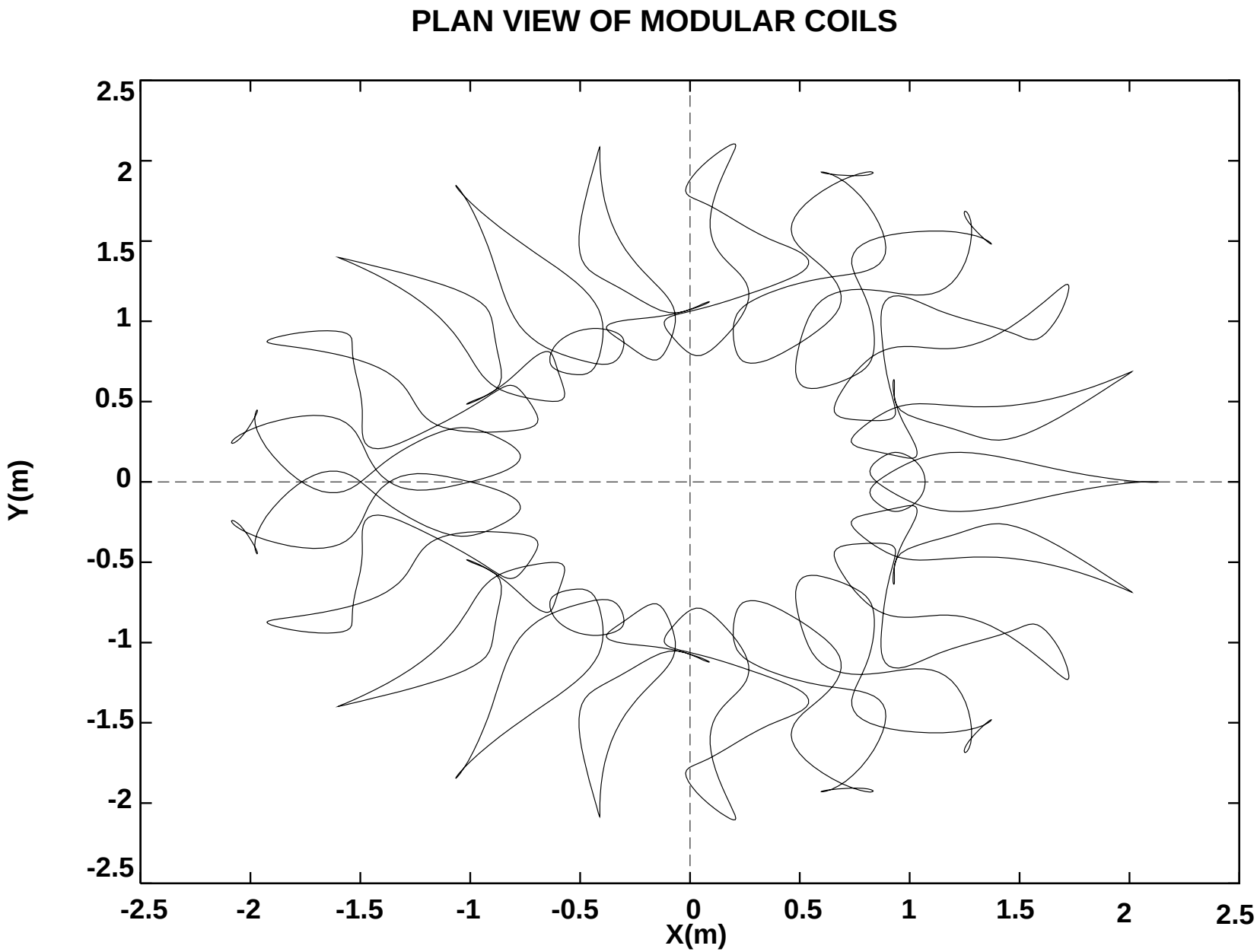

B normal errors for C82
"b_norm.dat"
0.342
0.171
0
-0.171
-0.342
1
0.5
0
0
0.5
1
poloidal-u
toroidal-v

NORMAL FIELDS WITH MODULAR COILS BOTH RIPPLE AND NEED FOR SADDLE LIKE COILS ARE APPARENT




Modular Coils for C82
1
0.8
0.6
0.4
0.2
0
poloidal-u
0
0.2
0.4
0.6
0.8
1
toroidal-v


PLAN VIEW OF MODULAR COILS
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
Y(m)
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
X(m)

BOTH MODULAR AND SADDLE COILS WERE INCLUDED IN A QOS OPTIMIZATION

- Seven modular coils (per period) were started on an 18 cm surface.
- Two saddle coils were started on a 12 cm surface.
- The modular coil surface was allowed to vary with a 15cm minimum distance to the plasma.
- Results:
  - plasma coil minimum: 14.5 cm
  - average error: 0.036
  - peak error: 0.133

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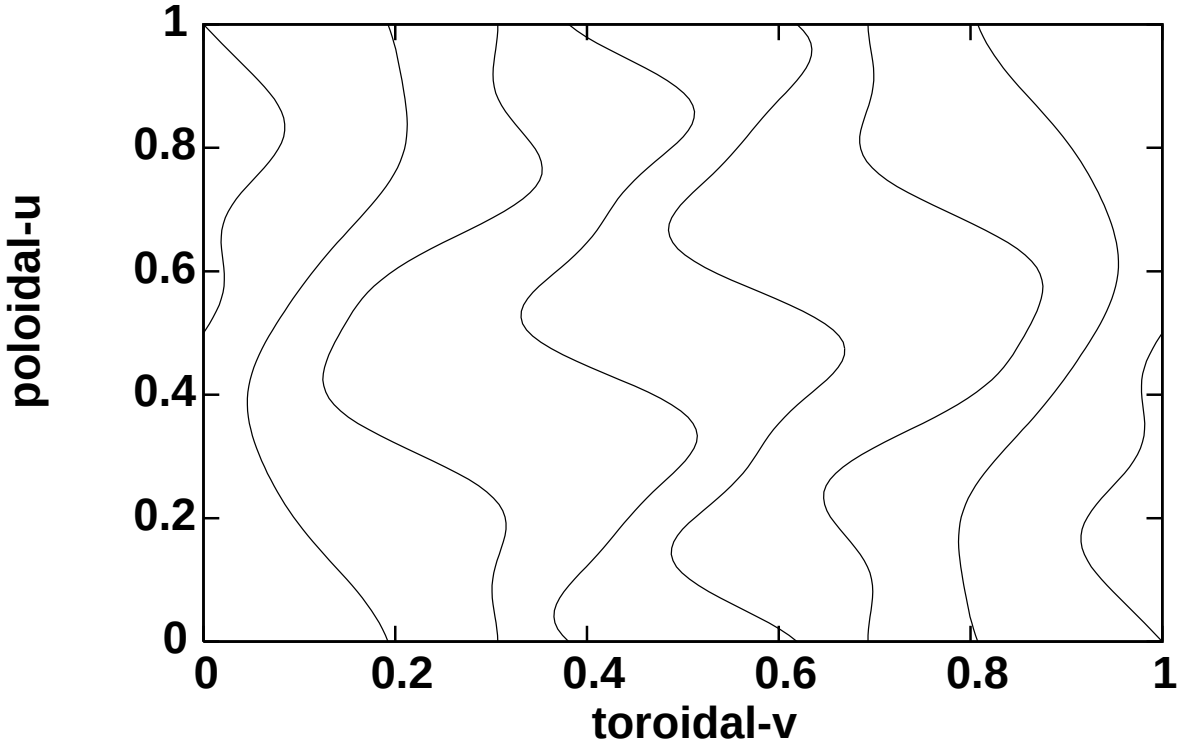
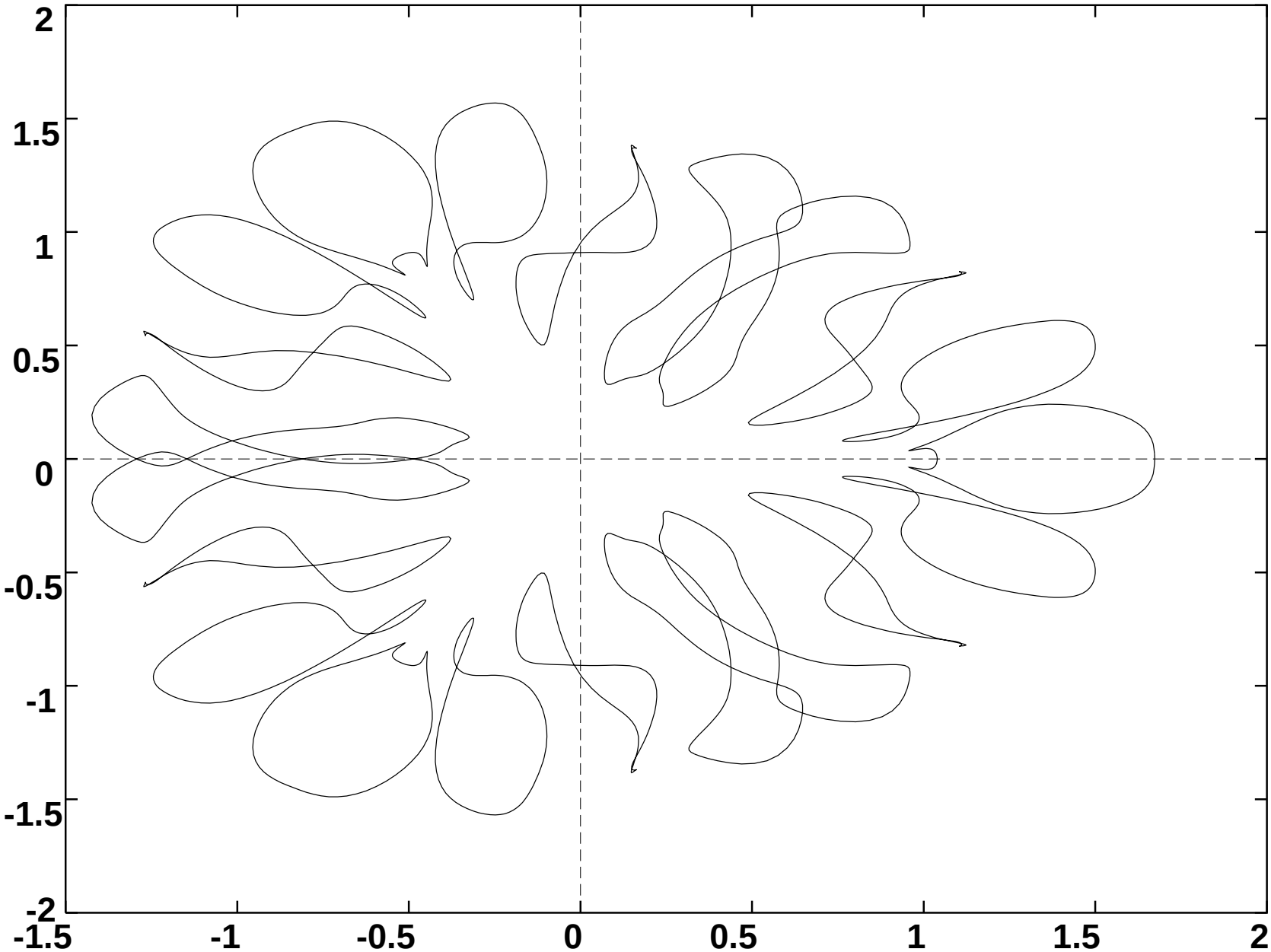
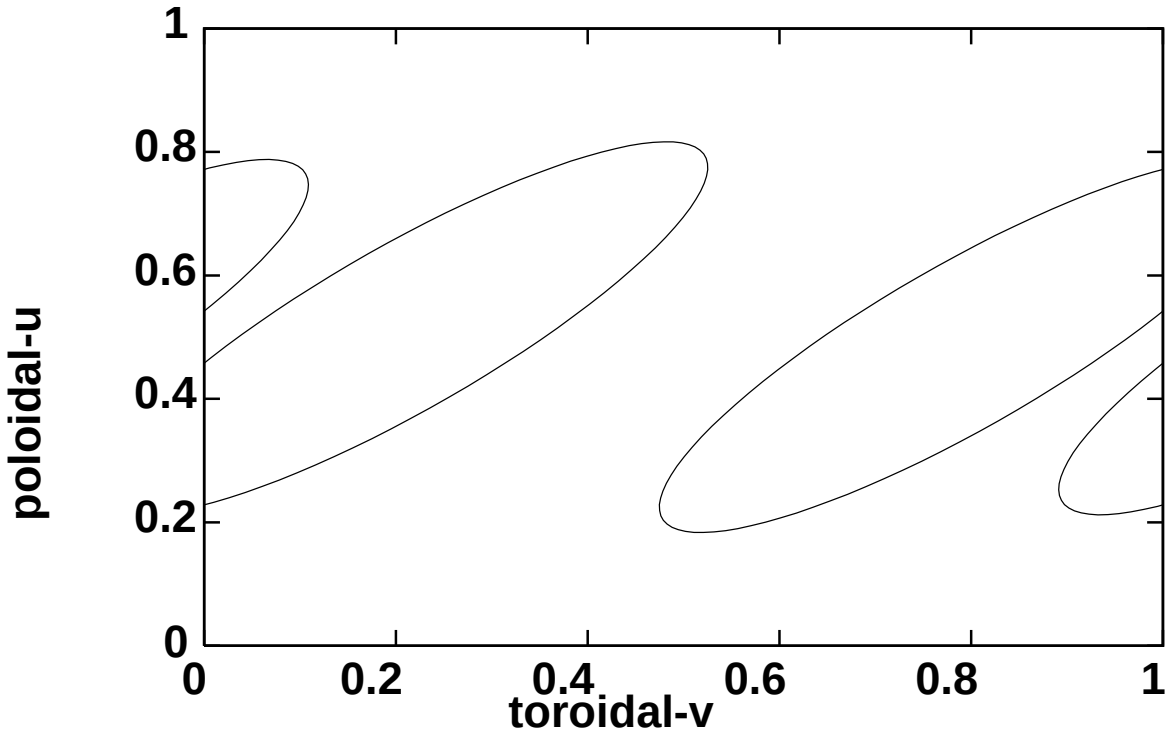
THE COMBINATION OF MODULAR AND SADDLE COILS HAS SIMPLIFIED THE MODULAR COILS

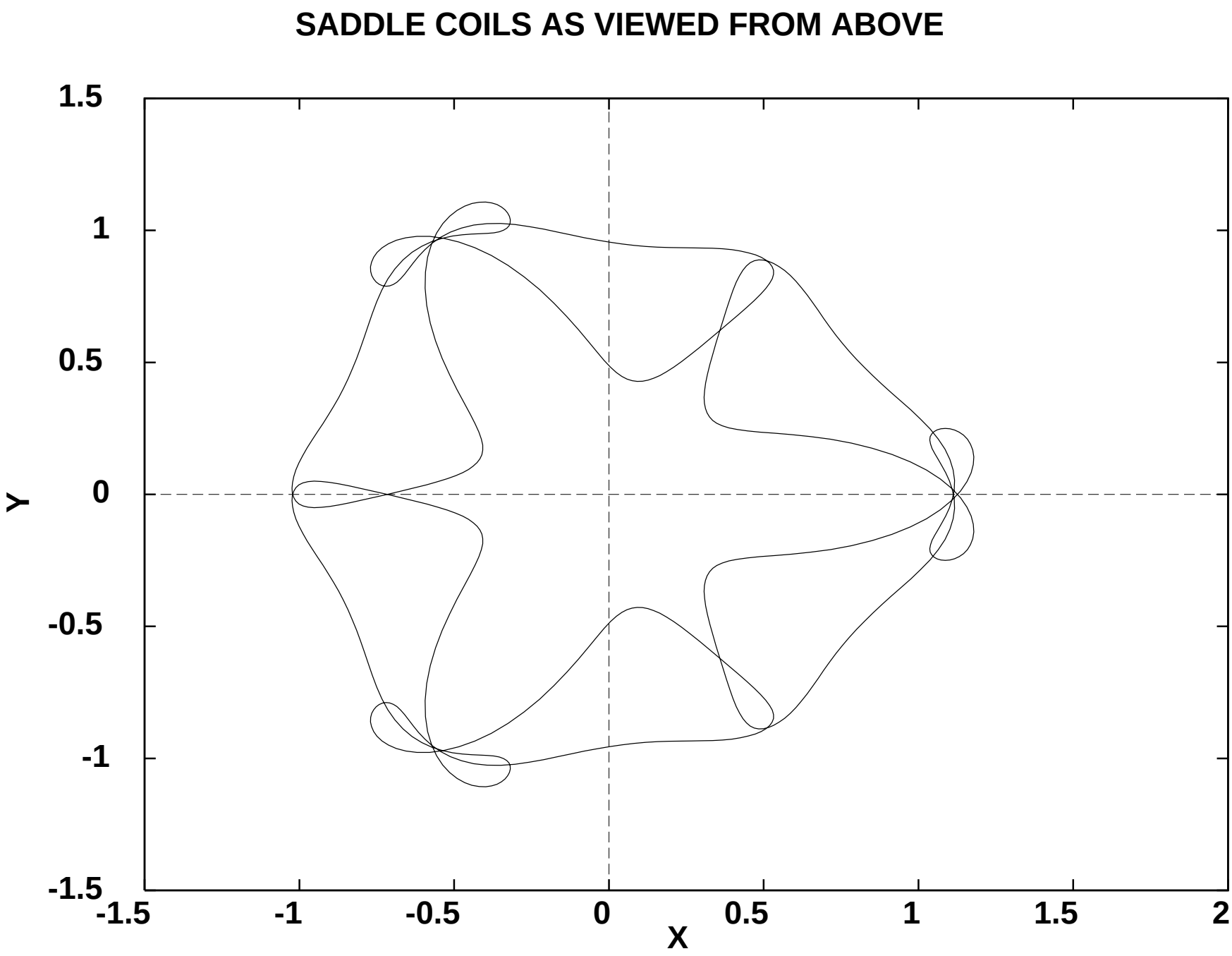


MODULAR COILS ON AN OPTIMIZED SURFACE



SADDLE COILS ON A 12 CM WINDING SURFACE




SADDLE COILS AS VIEWED FROM ABOVE
1.5
1
0.5
0
-0.5
-1
-1.5
Y
-1.5
-1
-0.5
0
0.5
1
1.5
2
X

SUMMARY/FUTURE PLANS/ISSUES

- **Winding surfaces with relatively few parameters and low errors can be generated.**
- **Coil design issues are beginning to be addressed using the increased capability of COILOPT.**
- **A more detailed saddle coil representation is needed that will allow readily-evaluated current density and geometry targets. Possibilities include:**
  - **more detailed parametric descriptions, both Fourier and algebraic, have attractive features;**
  - **use of coils cut from "potentials" where the potential is itself varied.**
- **Additional coil types, e.g. TFs of various sorts, may be needed.**

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