Improvements in the Coil-Cutting Algorithm

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OLD COIL CUTTING METHOD

- NESCOIL ⇒ Current Potential $\Phi(u, v)$.
- N equally spaced contour values are chosen between Φ_{max} and Φ_{min}.
- Filamentary "coils" are laid along each contour, and equal currents are assigned to the N coils.

After this assignation, fields from the N coils are calculated and the associated "error" at the plasma surface is determined.

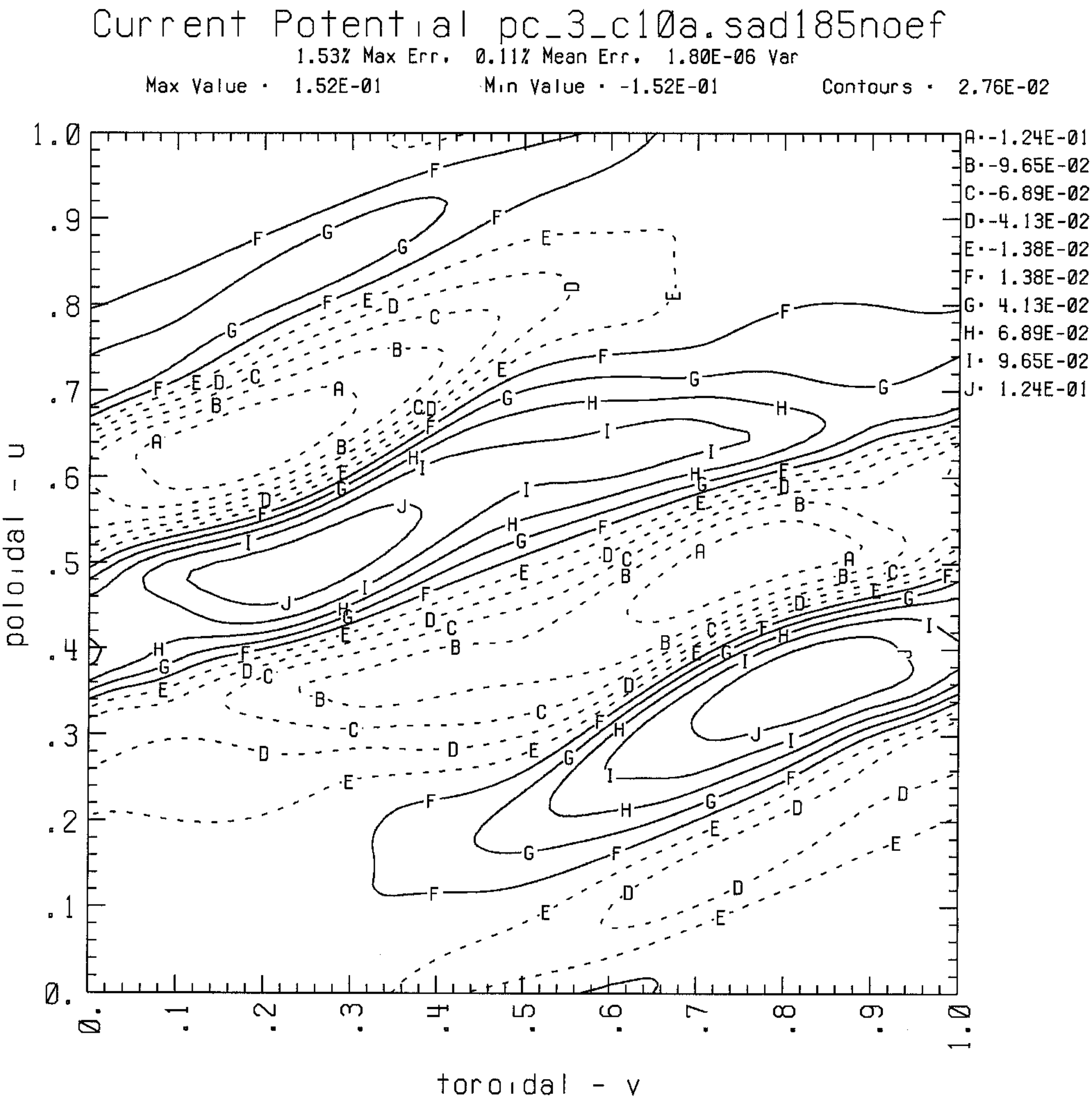
NEW COIL CUTTING CODE - NESCOILCUT

- Begin with the NESCOIL $\Phi(u, v)$. It can be determined by minimizing B-field errors or resonant displacements. The method does not care!
- For an initial set of N contour values, Φ_j, we lay filamentary coils along the chosen contours.
- Coil currents, I_j, are determined that minimize some target function that expresses a good fit to the desired fields (or resonant displacements) at the plasma surface.
- Now iterate so that, at each step, the contour values are varied. Thus, we minimize $T(\Phi_1, \Phi_2, \cdots, \Phi_N)$, with respect to the Φ_j, producing an optimized set of coil locations and currents as output.
- I write this as a nonlinear optimization problem in N variables subject to N linear constraints which express the condition
  $\Phi_{min} < \Phi_1 < \Phi_2 < \cdots < \Phi_N < \Phi_{max}$.
- Results using NESCOILCUT indicate a factor of 2 decrease in the discretization error compared with the old method.
- The code also allows flexibility studies to be performed, where the coil geometry is frozen, and coil currents are sought which produce desired changes in the plasma configuration.

- Tokamaks use several independent power supplies for the shaping EF. If we want a flexible machine, we cannot expect the stellarator to require any less!

CURRENT SHEET SOLUTION FROM WHICH COILS ARE TO BE CUT

Figure 1



QAS3C10

7 CONTOURS

BLACK (SOLID) = ORIGINAL

RED (DASH) = OPTIMIZED

	MEAN(%)	MAX (%)
SHEET	0.13	1.53
ORIGINAL	1.47	9.95
OPTIMIZED	0.92	4.30

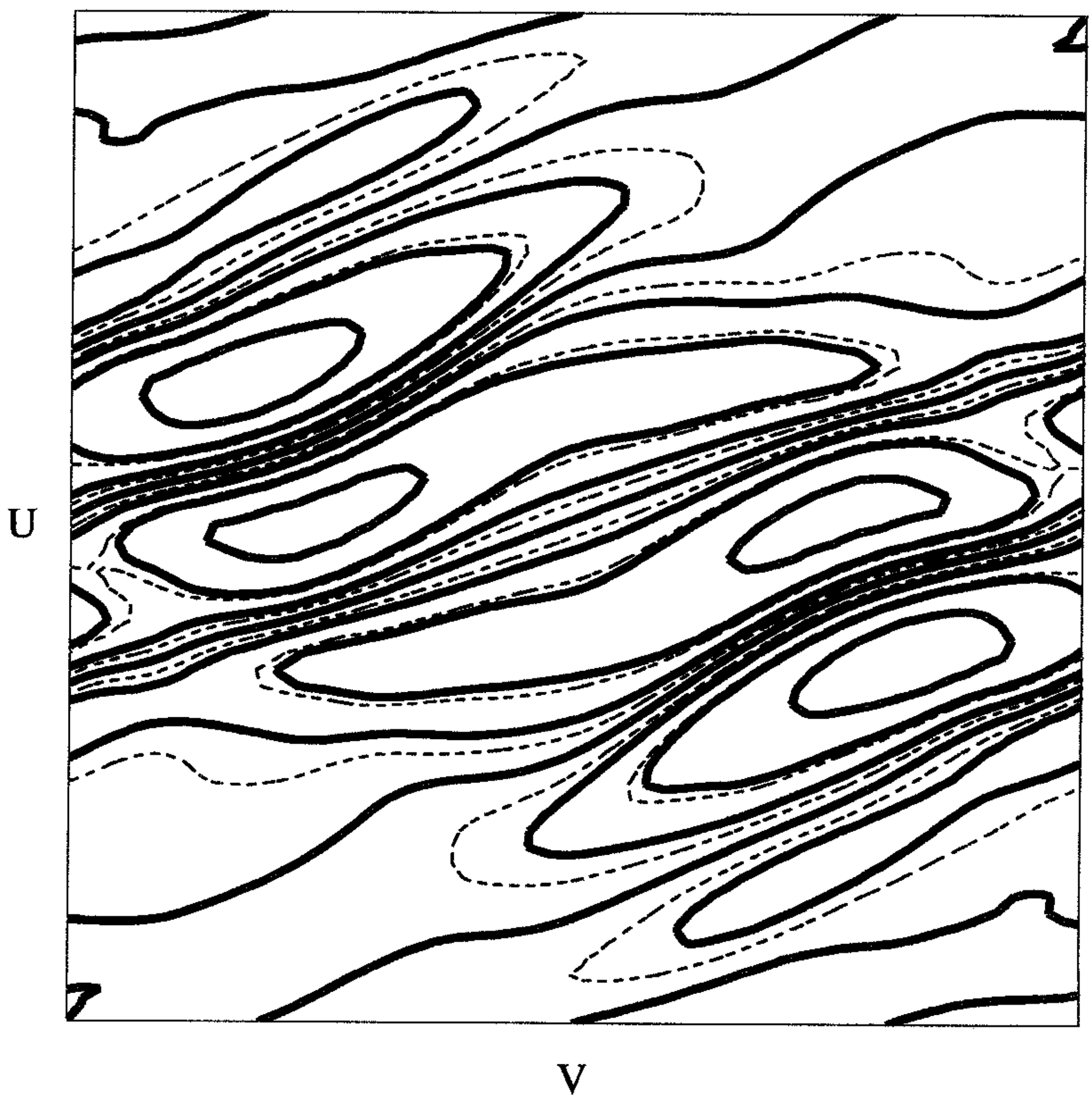


Figure 2

QAS3C10
11 CONTOURS

BLACK (SOLID) = ORIGINAL

RED (DASH) = OPTIMIZED

	MEAN(%)	MAX(%)
SHEET	0.13	1.53
ORIGINAL	0.85	5.98
OPTIMIZED	0.45	2.20

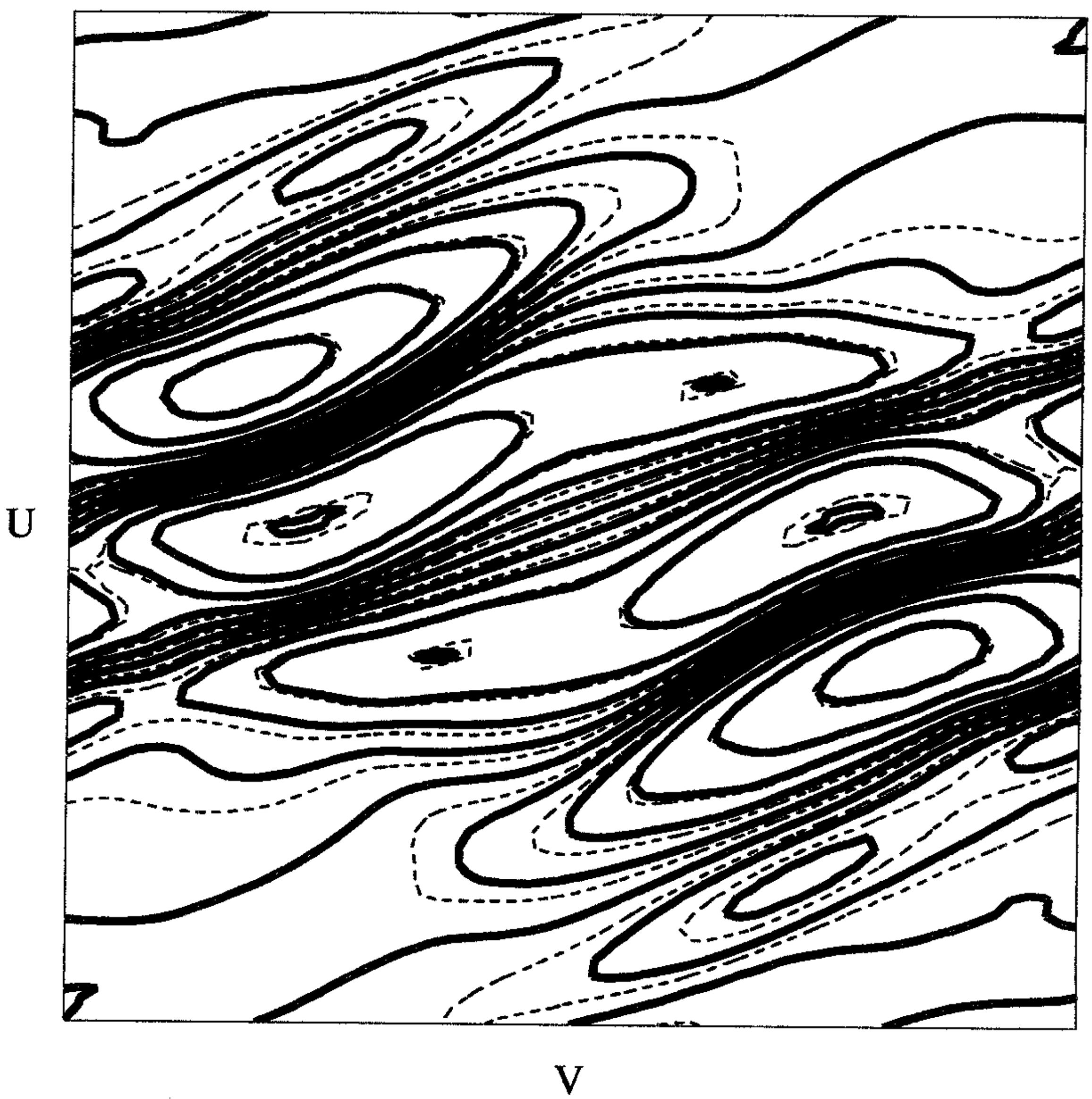


Figure 3

QHS3CIU

BLACK (SOLID) = ORIGINAL

8 CONTOURS

RED (DASH) = OPTIMIZED

	MEAN (%)	MAX (%)
SHEET	0.13	1.53
ORIGINAL	0.96	5.45
OPTIMIZED	0.74	3.75

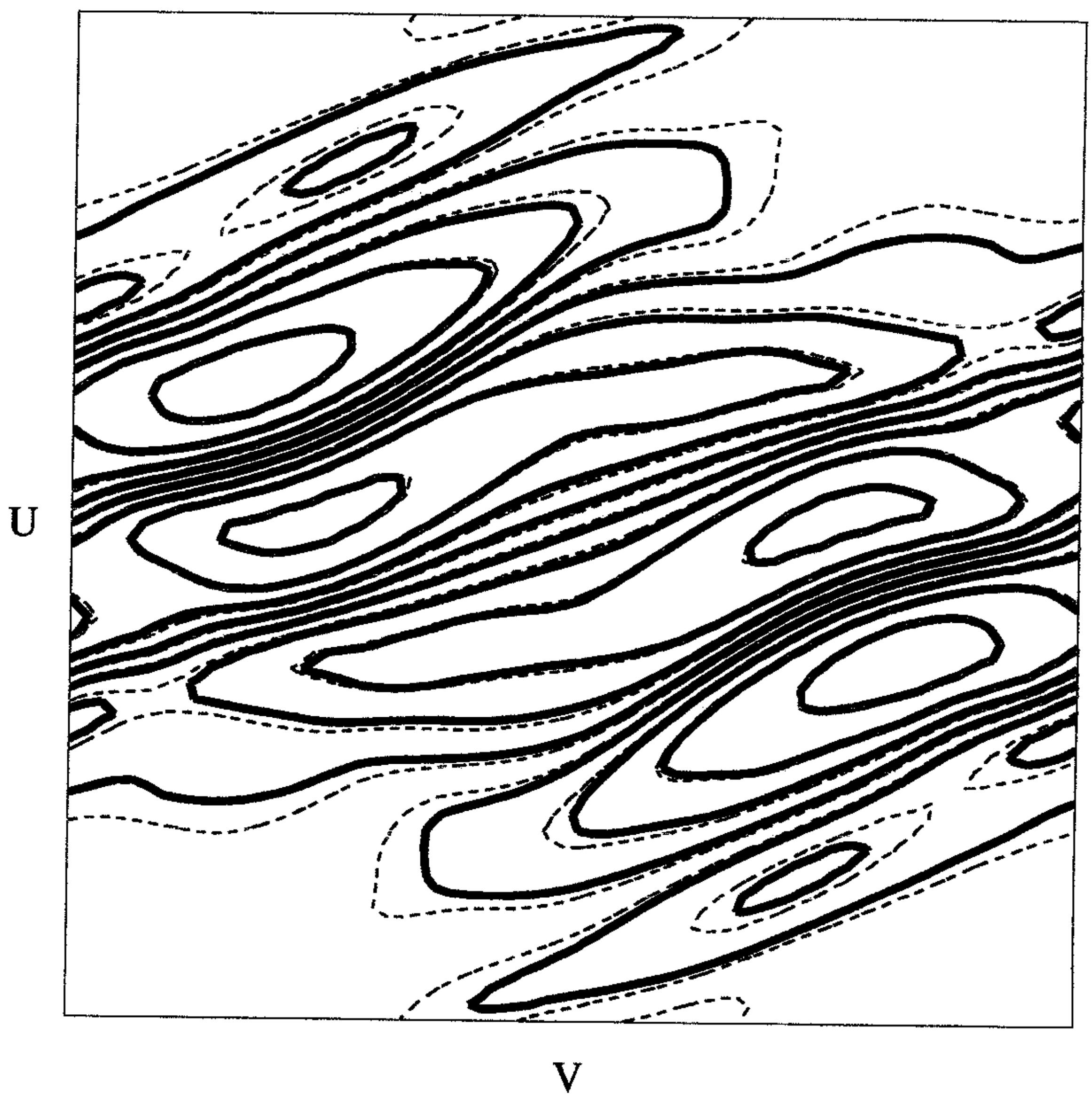
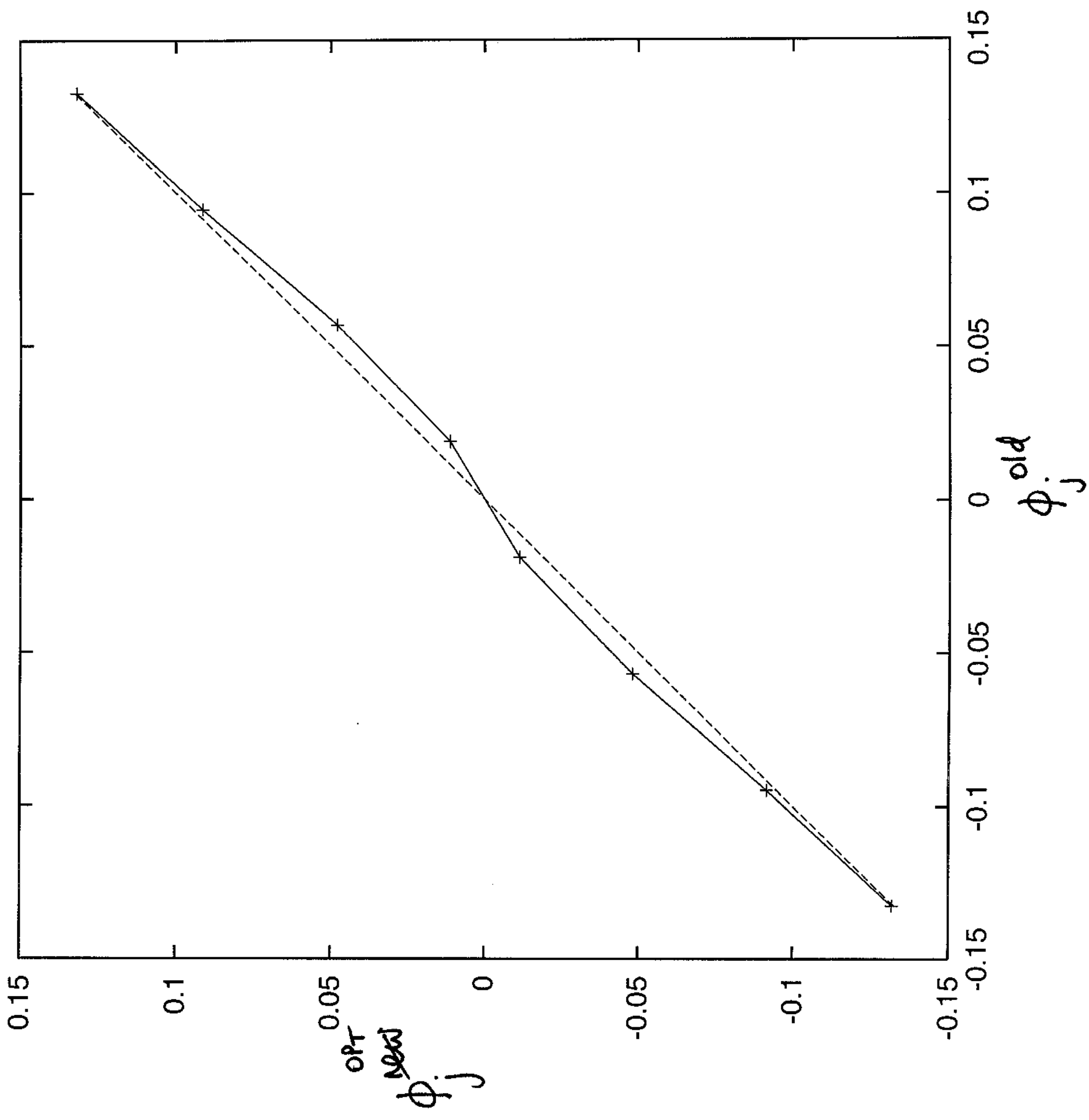


Figure 4

PAS3C10
8 CONTOURS

Figure 5



COMMENTS

- It appears that the optimized solution selects contours that "cover" the u-v plane better than the old method. In particular, the separatrix region is sampled.
  - This makes sense to me: The existence of X-points are a special characteristic of the topology of the current sheet solution.
- We will incorporate the resonant displacement error as a target.
- The code is ugly, but it works. It can easily be made considerably more efficient