STATUS REPORT ON TRIM COIL DESIGN FOR li383 BASED ON BOUNDARY COEFFICIENTS OBTAINED FROM PIES FOR INTERNAL ISLAND TARGETING

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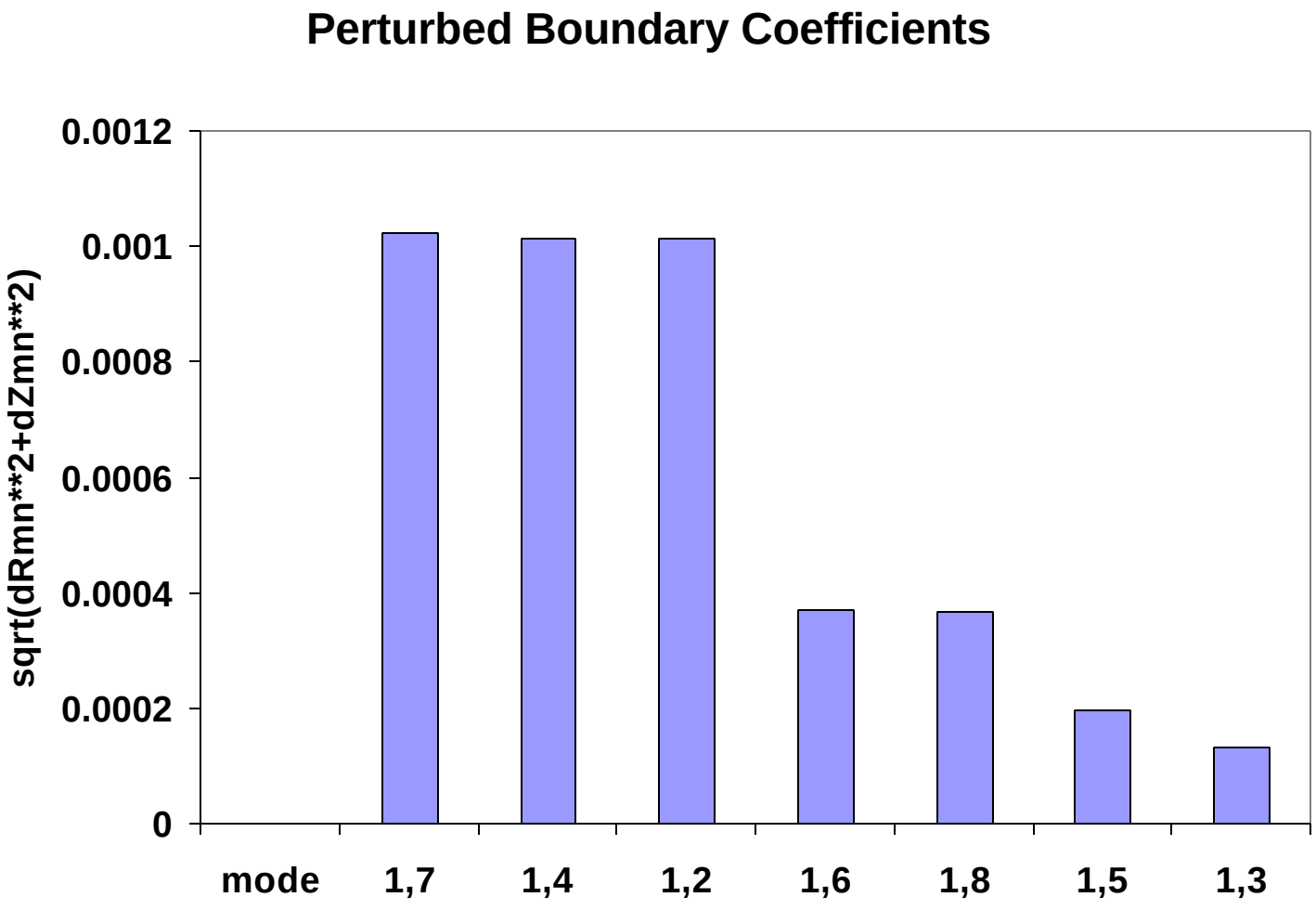
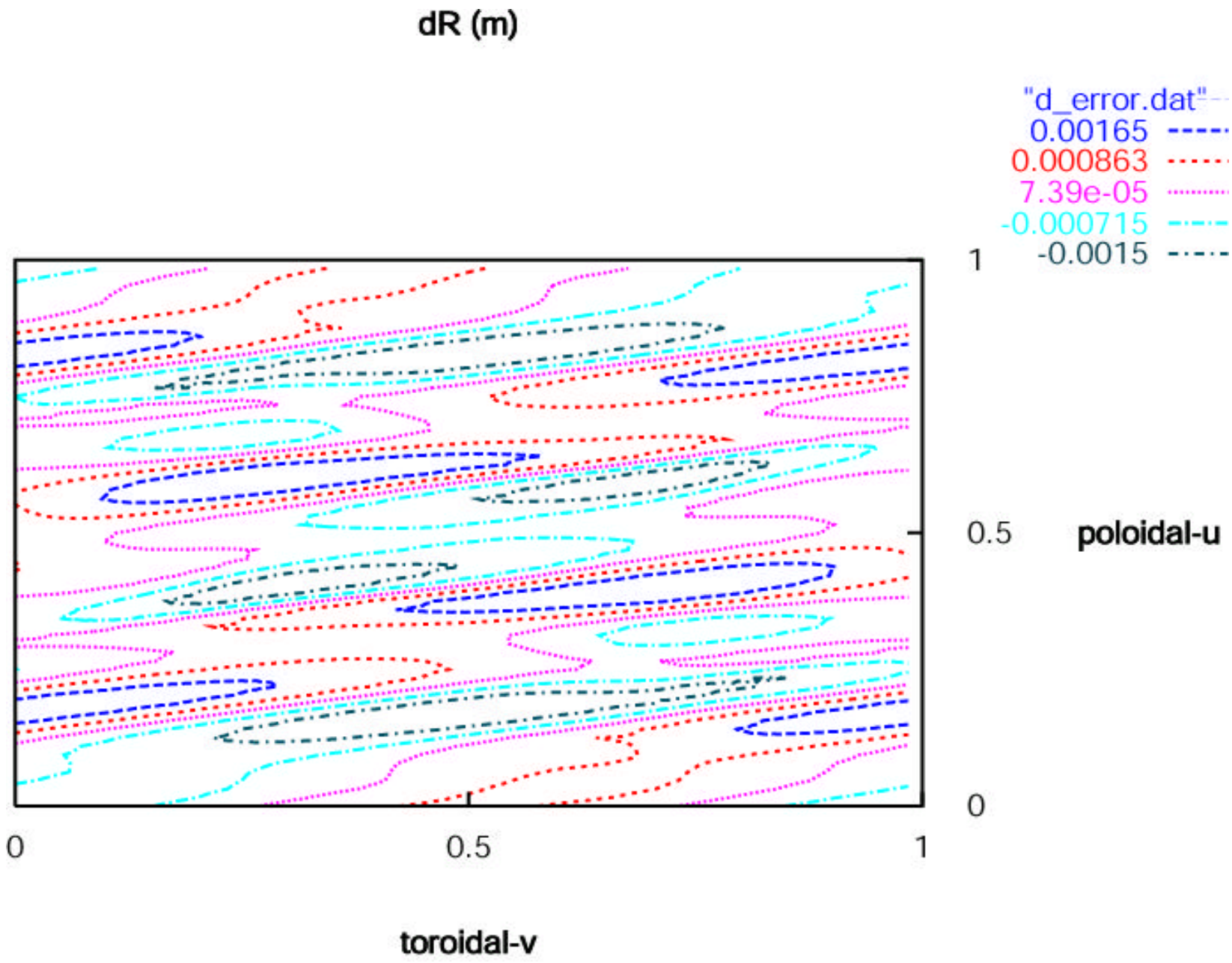
using data from Stuart Hudson

November 13, 2000


Perturbed Boundary Coefficients
sqrt(dRmn**2+dZmn**2)
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
mode
1,7
1,4
1,2
1,6
1,8
1,5
1,3


dR (m)
"d_error.dat"
0.00165
0.000863
7.39e-05
-0.000715
-0.0015
1
0.5
0
poloidal-u
0
0.5
1
toroidal-v

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BACKGROUND FOR ANALYSIS

- The data in the previous slide were obtained from

$$dr = \left(\boldsymbol{r}(u,v)_{\mathrm{mod}} - \boldsymbol{r}(u,v)\right)\cdot \boldsymbol{n}\,. \tag{1}$$

- The radial displacements are related to magnetic fields by

$$\frac{ddr}{dv} = \frac{\partial dr}{\partial v} + \frac{\partial dr}{\partial u}\frac{du}{dv} = \frac{B_{\perp}}{B^{v}} \tag{2}$$

where

$$\frac{du}{dv} = \frac{i - l_{v}}{1 + l_{u}}\,.$$

- We extract the fields from the measured displacements using

$$\frac{B_{\perp}}{B^{v}} = \sum_{m,n} -dr_{mn}\sin(mu - nv)\left(m\frac{du}{dv} - n\right) \tag{3}$$

where

$$dr(u,v) = \sum dr_{m,n}\cos(mu - nv) \tag{4}$$

is obtained from the data in Eq. 1.

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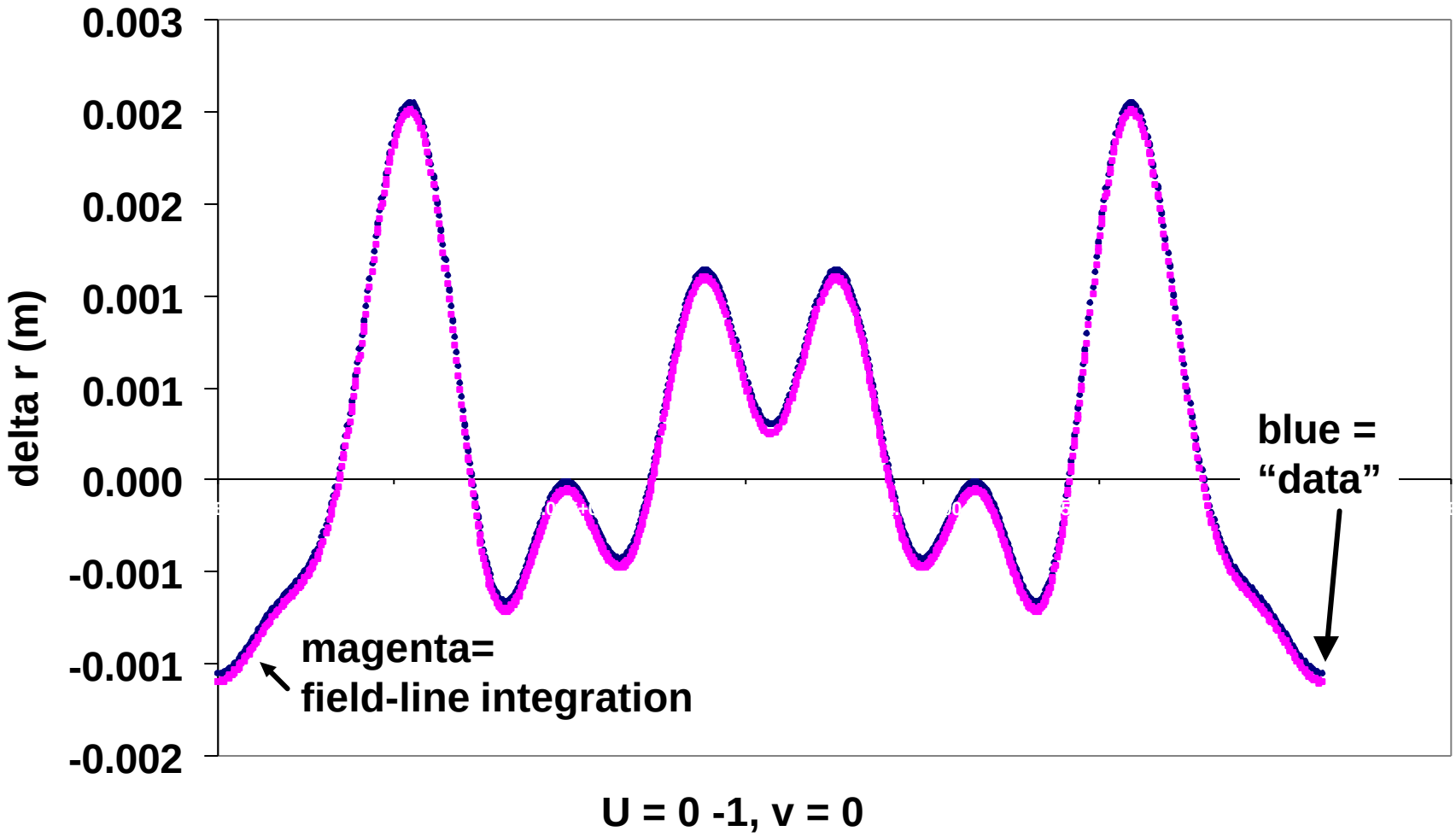
TO ENSURE SELF-CONSISTENCY,THE PERPENDICULAR FIELDS WERE INTEGRATED ALONG FIELD LINES TO RECONSTRUCT THE BOUNDARY DISPLACEMENTS

- **The boundary displacements were reasonably well represented by the n<=+/-5, m<=8 modes used for the equilibrium. RMS errors were ~0.25%. This set of modes was used for the reconstruction test.**
- **The plasma boundary displacements were defined by following field lines for 1000 periods.**
- **Good agreement was found**
  - **iota = 0.65599 from vmec and 0.65595 averaged over 1000 periods for;**
  - **excellent agreement with the delta-rs.**

Comparison of dr direct, integrated from B_p



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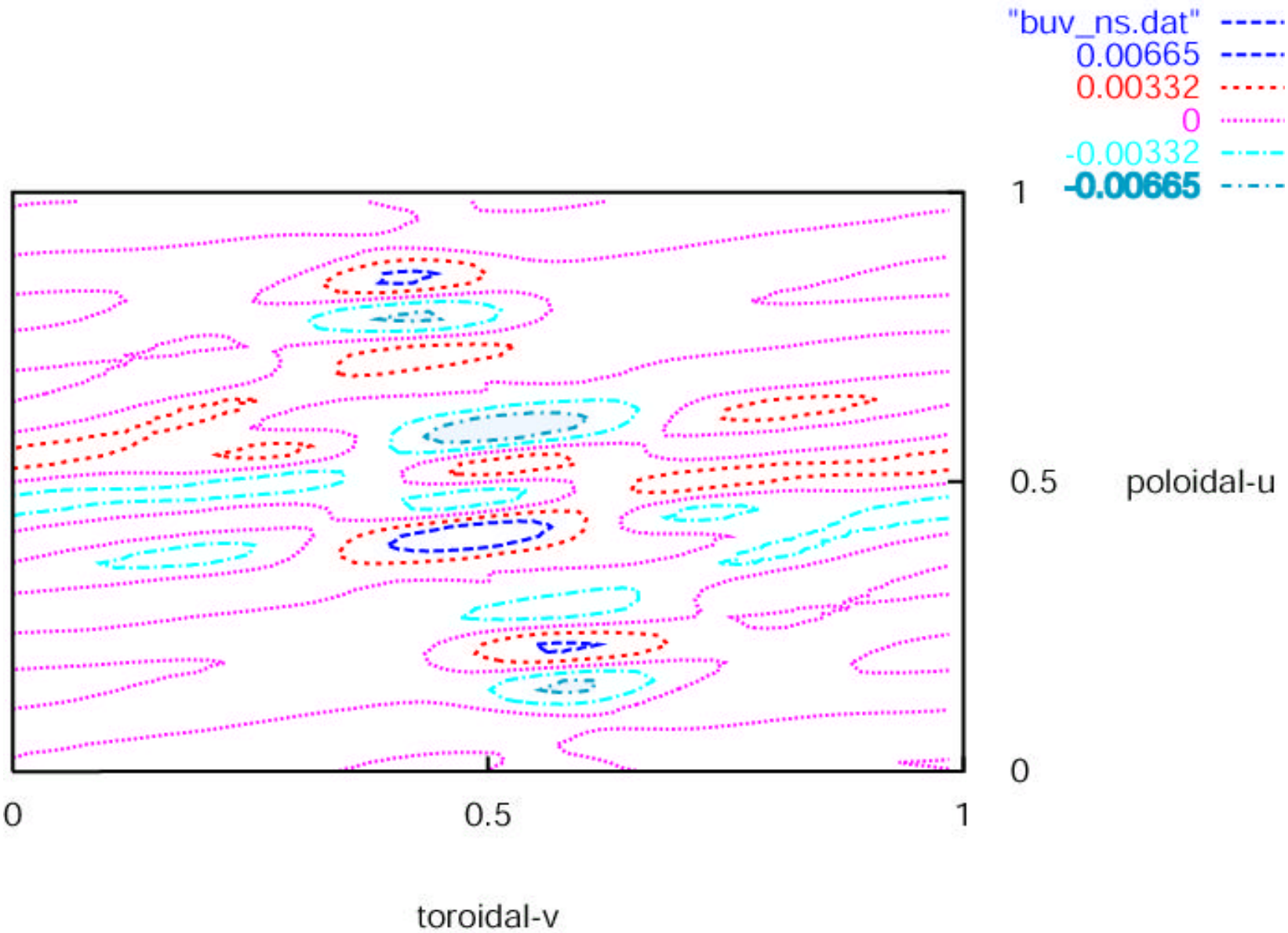
B-p/B-v (Non-straight Line)



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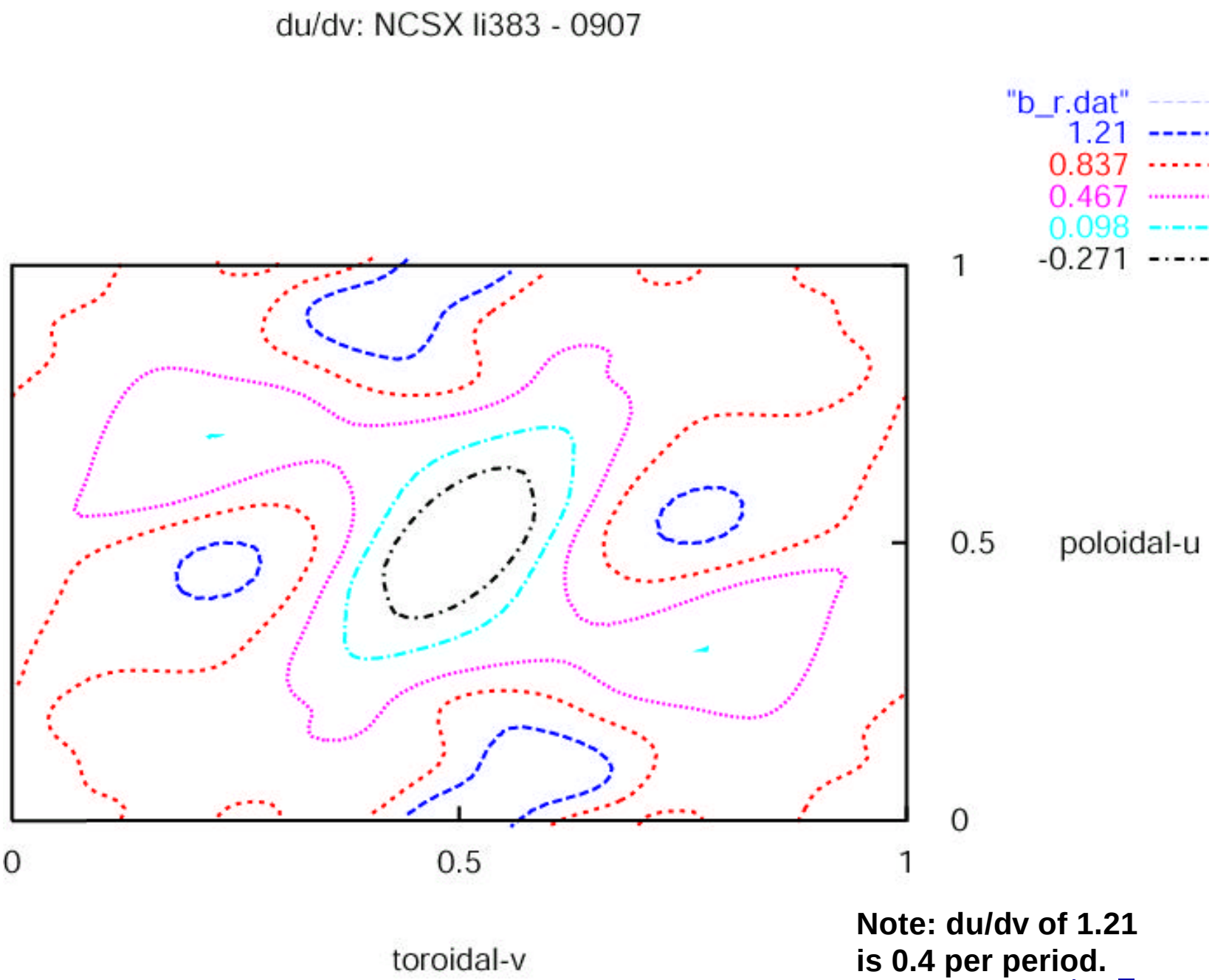
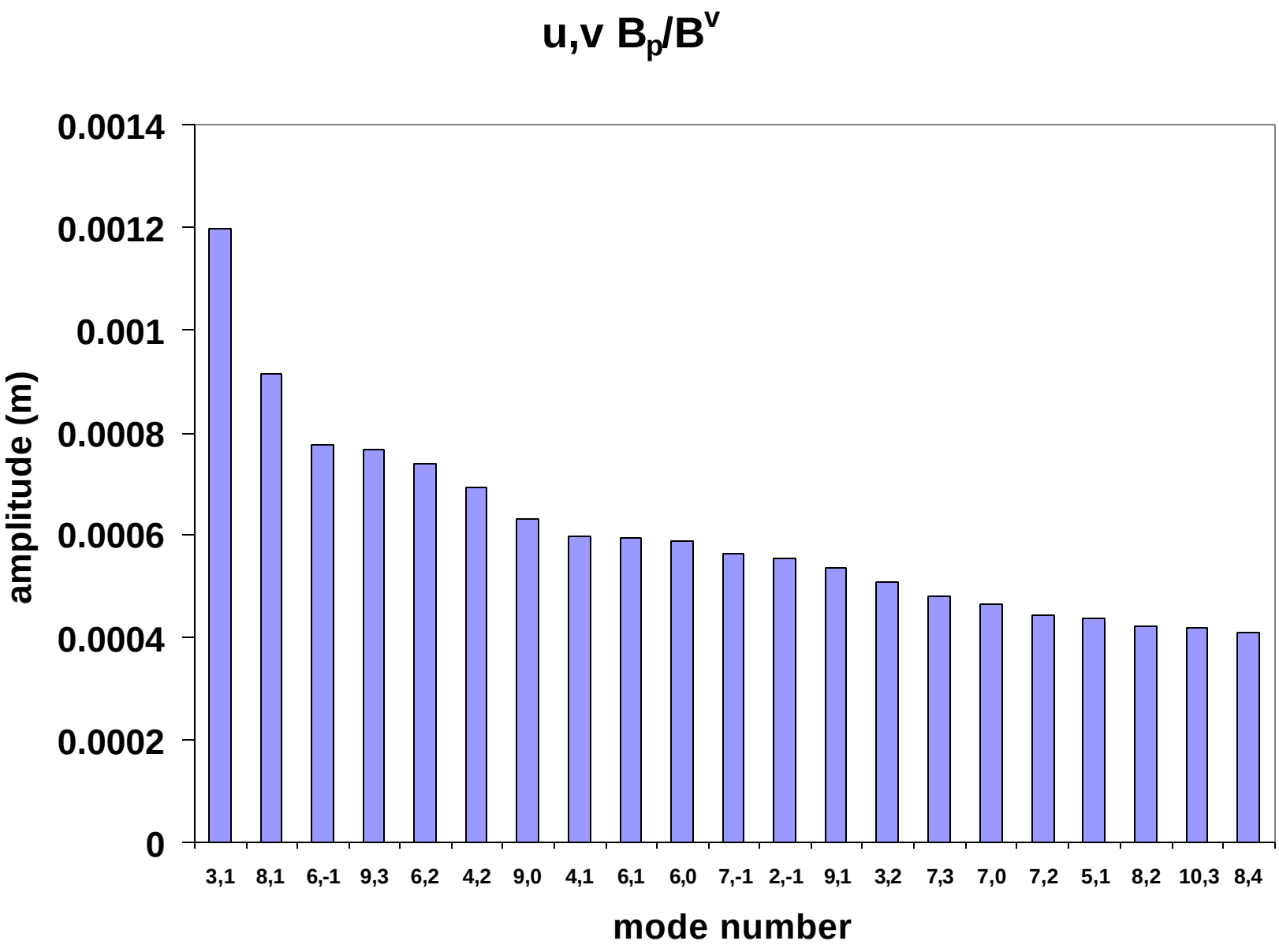
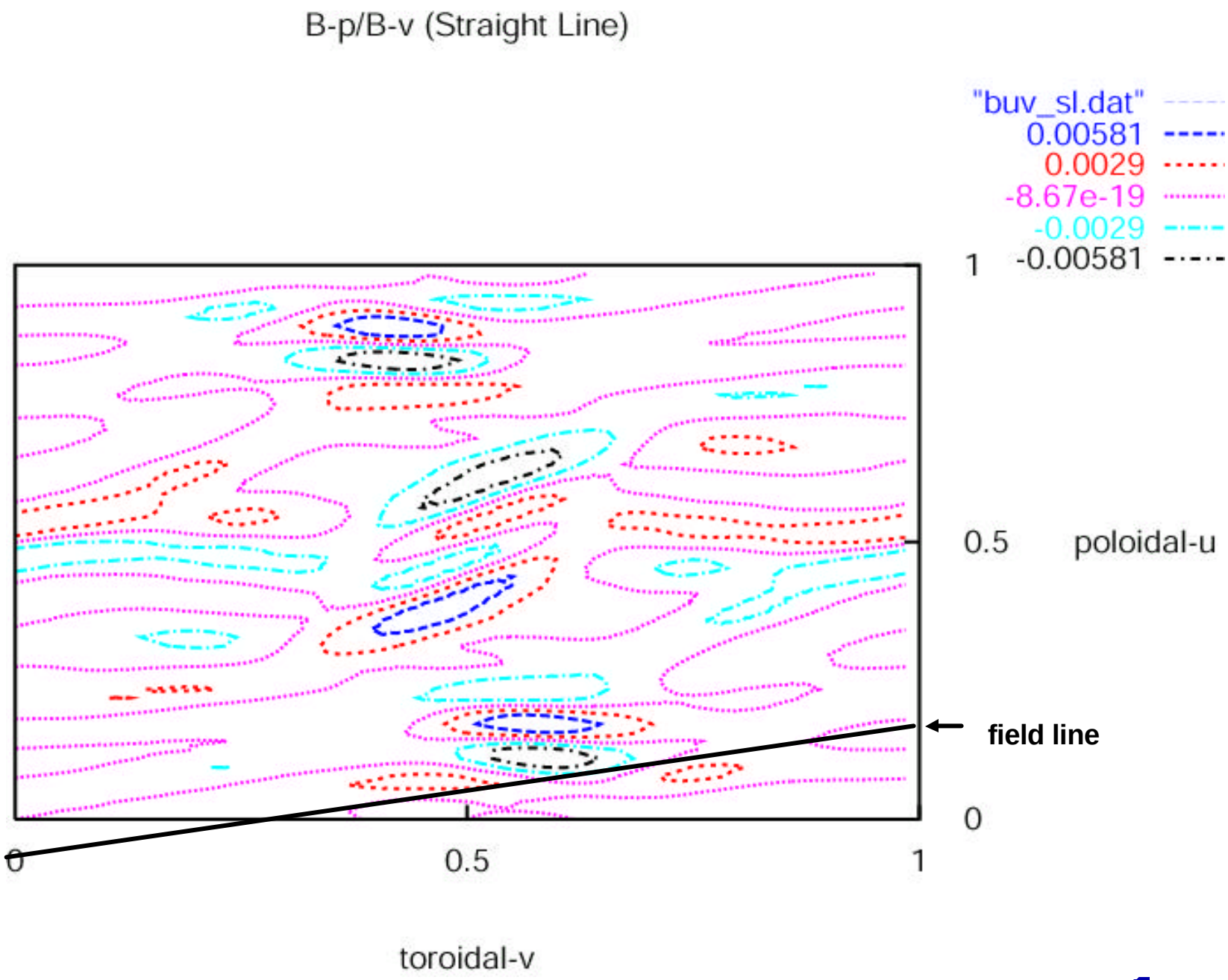
THE SPECTRUM OF B_{perp} HAS SIGNIFICANT COMPENTS PAST THE RANGE USED FOR THE EQUILIBRIUM

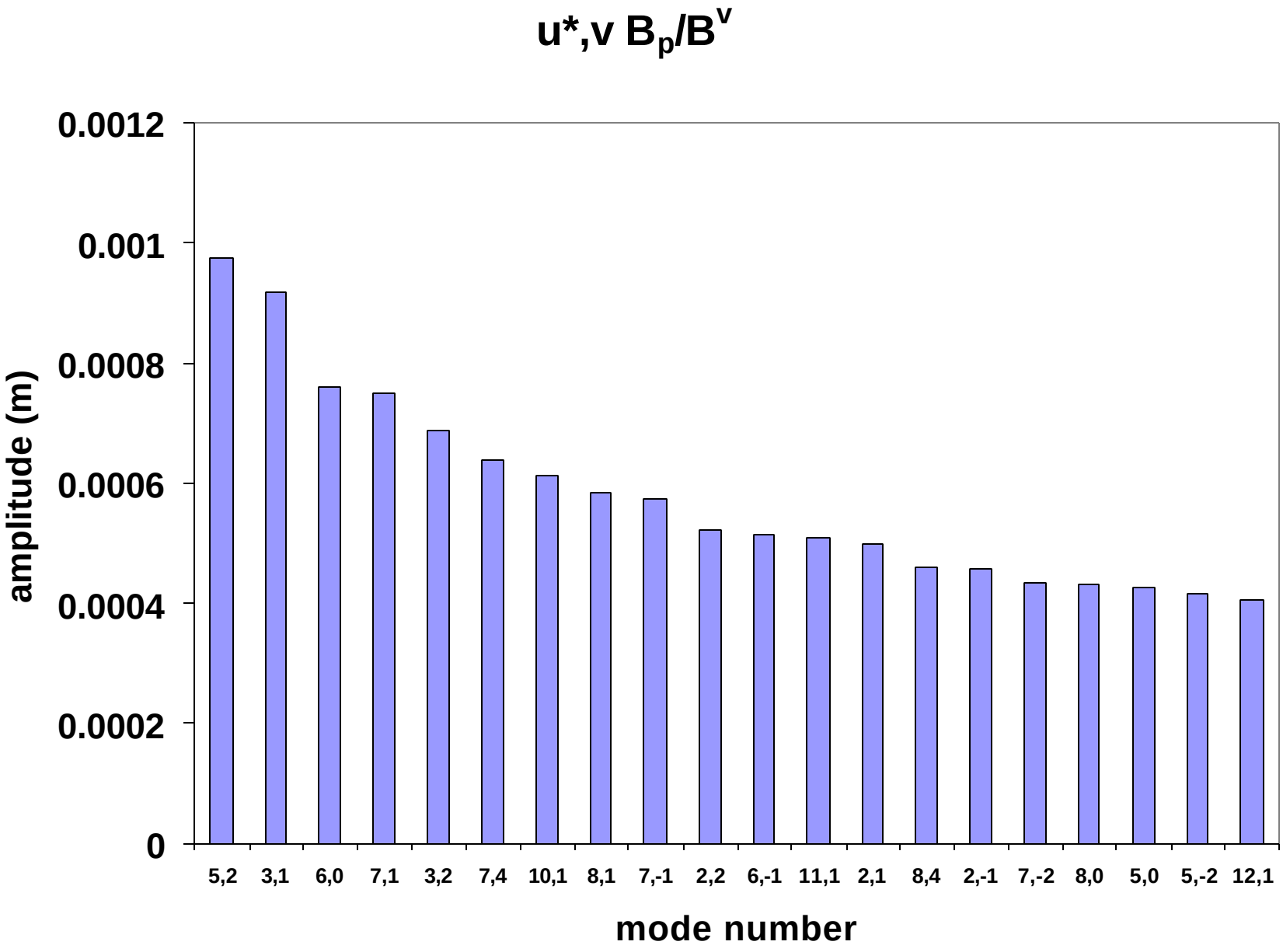
- **To fit data from, e.g., the previous slide, over twice the number modes used in the equilibrium (and to fit δr) was required.**
  - **~50% more for both u and v.**
- **This rich spectrum was driven by**
  - **broad m (u) spectrum in the perturbed boundary**
  - **derivatives in both u and v of the displacements;**
  - **product with du/dv that has broad n (v) spectrum.**

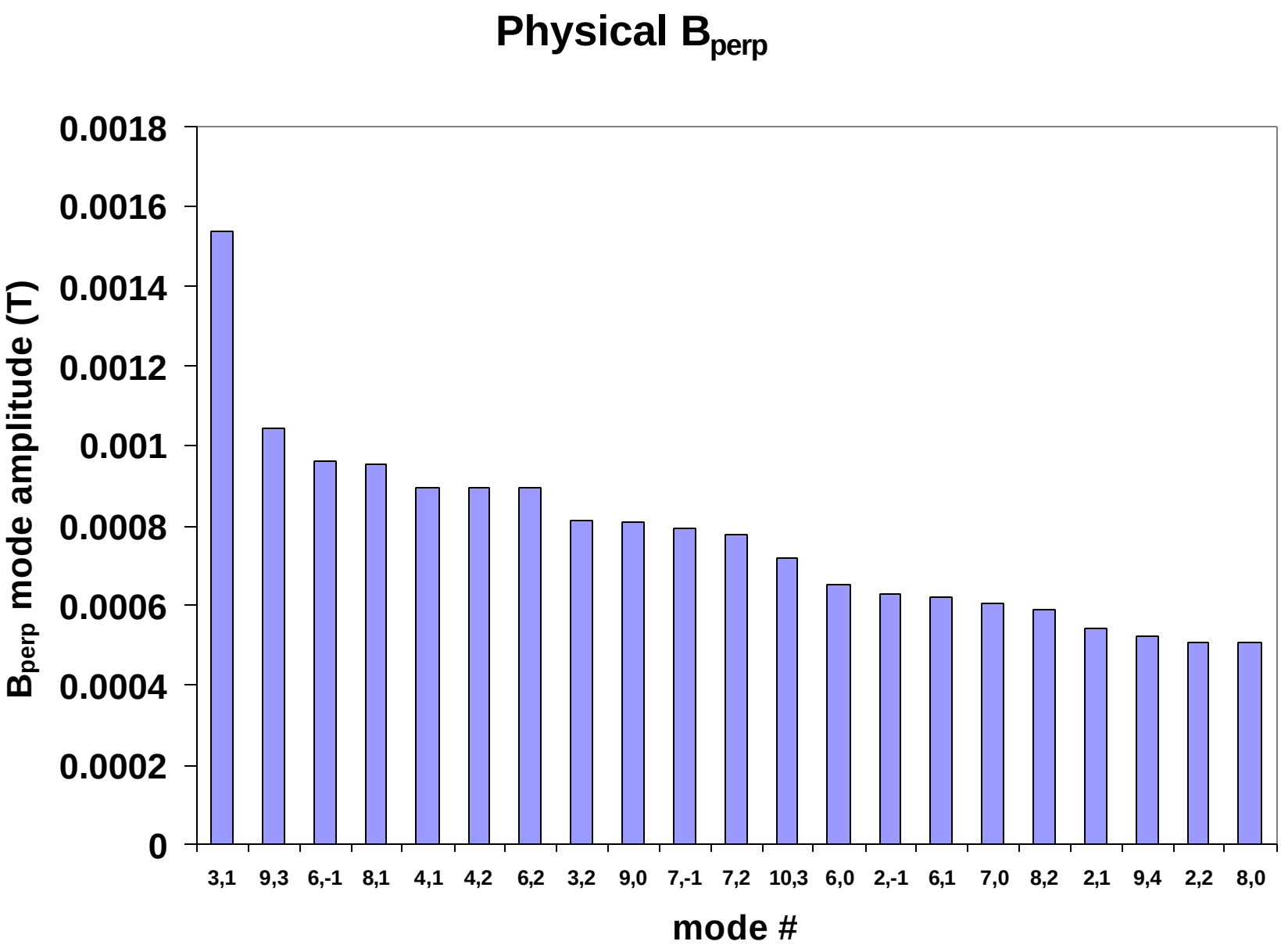


Note: du/dv of 1.21 is 0.4 per period.


u,v B_p/B^v
0.0014
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
amplitude (m)
3,1
8,1
6,-1
9,3
6,2
4,2
9,0
4,1
6,1
6,0
7,-1
2,-1
9,1
3,2
7,3
7,0
7,2
5,1
8,2
10,3
8,4
mode number


B-p/B-v (Straight Line)
"buv_sl.dat"
0.00581
0.0029
-8.67e-19
-0.0029
-0.00581
1
0.5
poloidal-u
field line
0
0
0.5
1
toroidal-v


u*,v Bp/Bv
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
amplitude (m)
5,2
3,1
6,0
7,1
3,2
7,4
10,1
8,1
7,-1
2,2
6,-1
11,1
2,1
8,4
2,-1
7,-2
8,0
5,0
5,-2
12,1
mode number

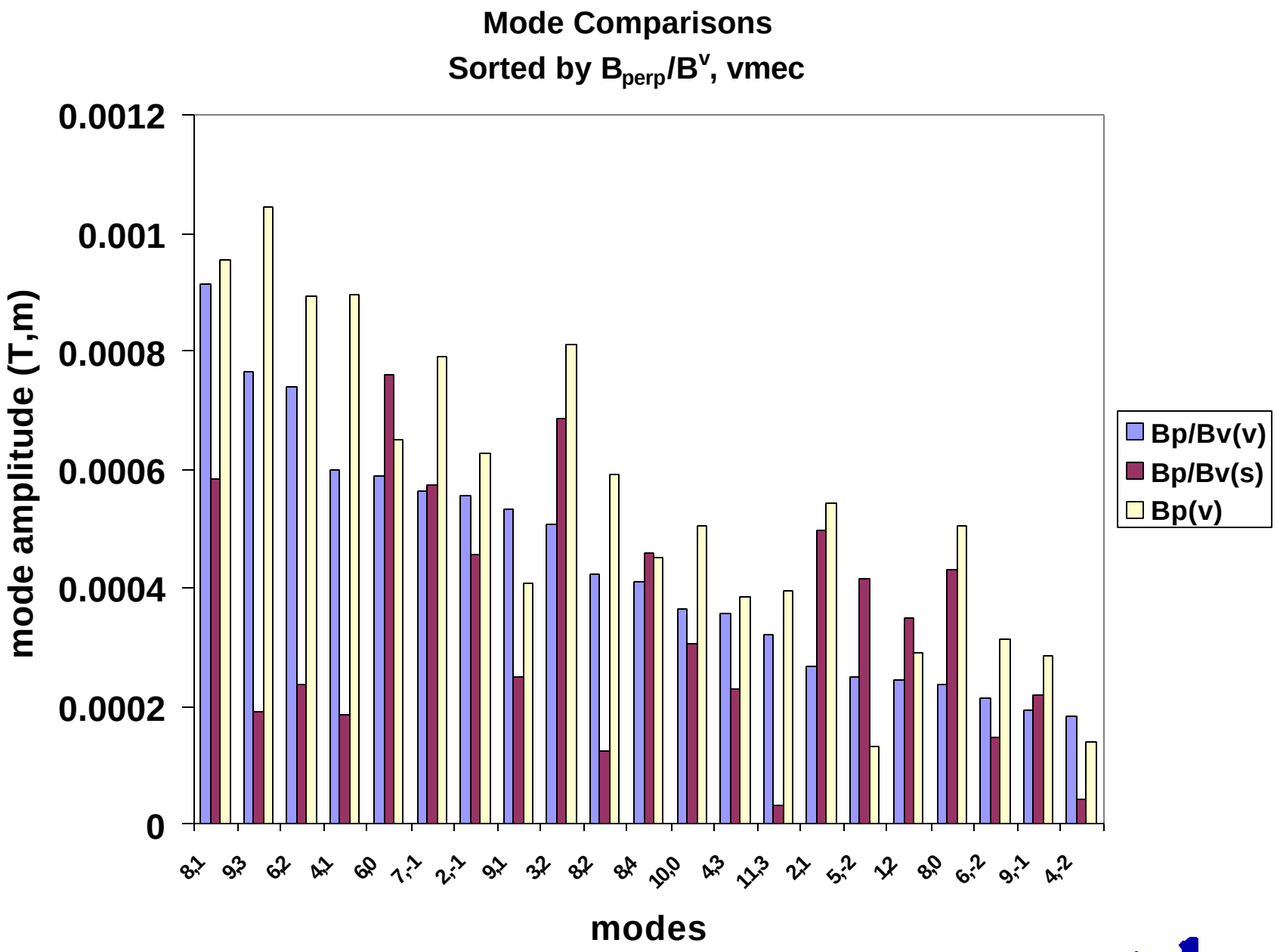

Physical B_{perp}
0.0018
0.0016
0.0014
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
B_{perp} mode amplitude (T)
3,1
9,3
6,-1
8,1
4,1
4,2
6,2
3,2
9,0
7,-1
7,2
10,3
6,0
2,-1
6,1
7,0
8,2
2,1
9,4
2,2
8,0
mode #

PLANS

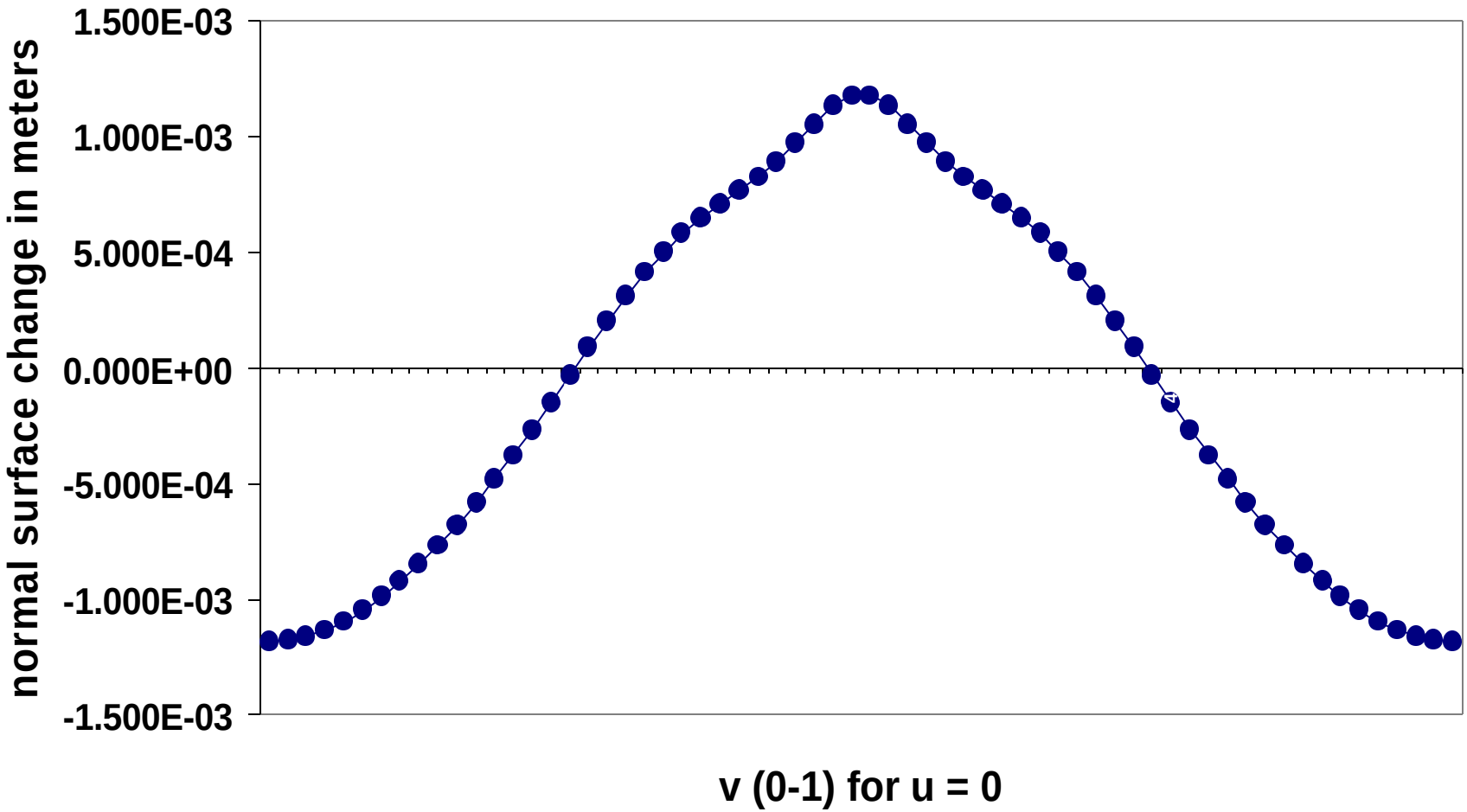
- **Obtain boundary data for the situation where the plasma boundary is well-behaved, but there are internal islands.**
- **Rather than using the full set of $B_{perp,mn}$, take advantage of Stuart's "importance" matrix that relates the delta Rs and Zs to particular islands. Then:**
  - **choose the most worrisome island;**
  - **find the Rs and Zs that go with that island;**
  - **find the B_{perps} spectral components that follow from those Rs and Zs;**
  - **target that linear combination in COILOPT.**

SUMMARY

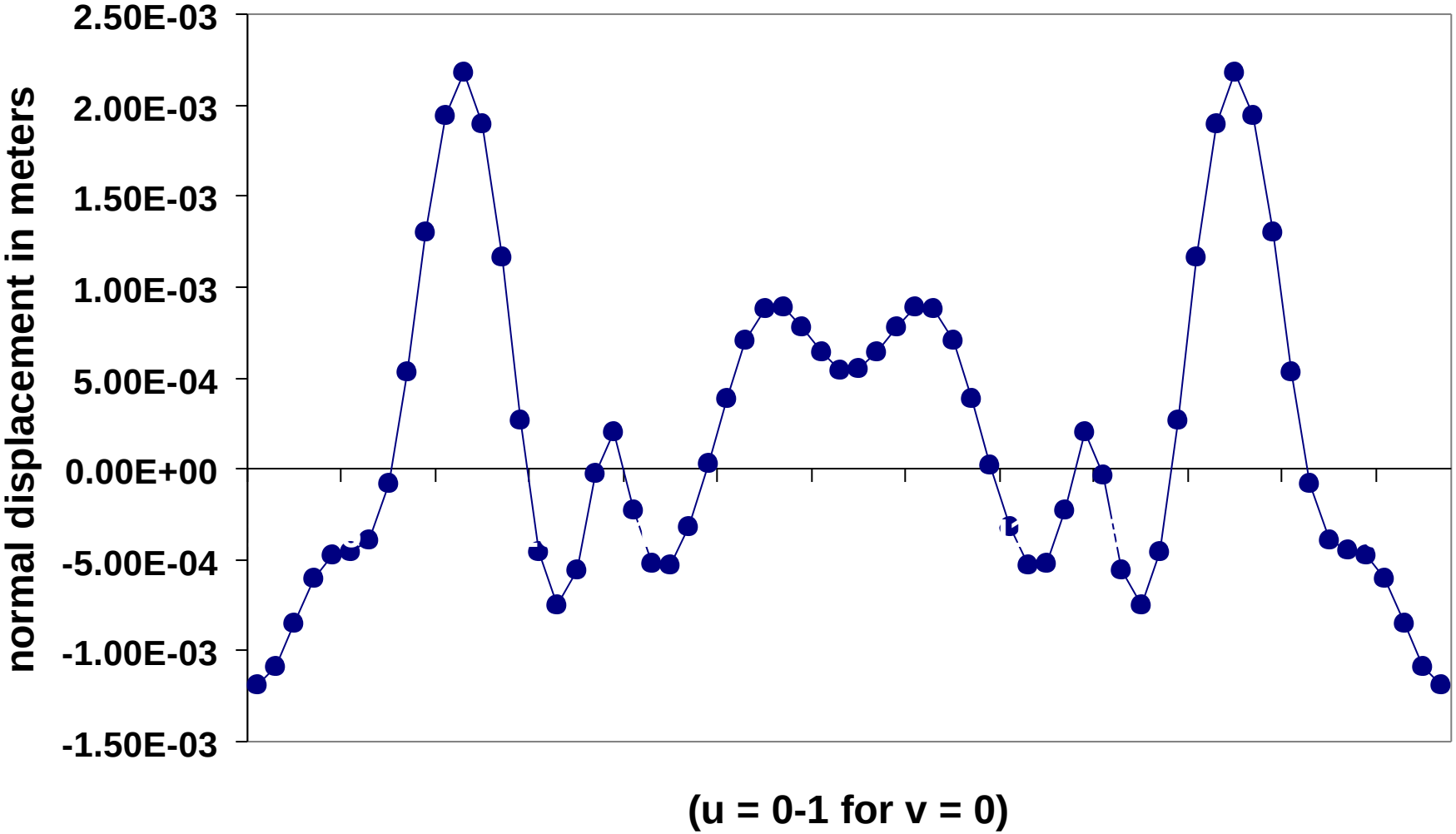
- **Equilibrium perturbations (R_{mn}s and Z_{mn}s) from Stuart Hudson have been used to estimate the external normal fields that are necessary to produce the island healing observed in Stuart's calculations.**
- **These fields were checked by reconstructing the original displacements.**
- **Spectra of resulting fields are broad with no dominant modes.**


Mode Comparisons
Sorted by B_{perp}/B^{v}, vmec
mode amplitude (T,m)
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
8,1
9,3
6,2
4,1
6,0
7,-1
2,-1
9,1
3,2
8,2
8,4
10,0
4,3
11,3
2,1
5,-2
1,2
8,0
6,-2
9,-1
4,-2
modes
Bp/Bv(v)
Bp/Bv(s)
Bp(v)

surface change for healed surfaces, per S. Hudson



surface change for healed surfaces, per S. Hudson



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