POSTER Session VP1 - Poster Session X. [VP1.052]
Thursday afternoon,
October 26 Exhibit Hall AB,
Québec City Convention Centre

Lower Hybrid Current Drive and Heating for the National Transport Code Collaboration

D.W. Ignat, S.C. Jardin, D.C. McCune, E.J. Valeo
(Princeton Plasma Physics Laboratory)

The Lower hybrid Simulation Code LSC was originally written as a subroutine to the Toroidal Simulation Code TSC (Jardin, Pomphrey, Kessel, et al) and subsequently ported to a subroutine of TRANSP. Modifications to simplify the use of the LSC both as a callable module, and also independently of larger transport codes, and improve the documentation have been undertaken with the goal of installing LSC in the NTCC library. The physical model, which includes ray tracing from a Brambilla spectrum, 1D Fokker-Planck development of the electron distribution, the Karney-Fisch treatment of the electric field, heuristic diffusion of current and power and wall scattering, has not been changed. The computational approach is to suppress or remove from the control of the user numerical parameters such as step size and number of iterations while changing some code to be extremely stable in varied conditions. Essential graphics are now output as **gnuplot** commands and data for off-line post processing, but the original outputs to `sglib` are retained as an option. Examples of output are shown.

SIGN-UP SHEET

for VP1.052: LSC for NTCC,
by
Ignat, Jardin, McCune, Valeo

Name	Address	Email

Thanks,
David W Ignat
(ignat@pppl.gov for LSC / PPPL business)
(ignat@aya.yale.edu for *Nuclear Fusion* and other business)

Some published descriptions and uses of LSC

1. D. W. Ignat, E. J. Valeo, and S. C. Jardin, "Dynamic Modeling of Lower Hybrid Current Drive," Nucl. Fusion **34** 837-852 (1994).
2. F. Paoletti, D. W. Ignat, J. Kesner, S. Bernabei, R. Kaita, B. LeBlanc, F. M. Levinton, and S. C. Luckhardt "LHCD Accessibility Study with Reconstructed Magnetic Equilibria in PBX-M," Nucl. Fusion **34** 771-776 (1994).
3. D. W. Ignat, R. Kaita, S. C. Jardin, and M. Okabayashi, "Spreading of Lower Hybrid Wave Driven Currents in PBX-M," Nucl. Fusion **36** 1733-1742 (1996)

LSC — 2000
Goals and Status

#	GOAL	STATUS
1	Bring the LSC into the NTCC	Successful multi-platform compilation and successful test computations with TSC. Manual improved and enlarged.
2	Put graphics in data files for later processing with portable tools.	Graphics now written as combined **gnuplot** commands and data for off-line processing.
3	Reduce the number of NAMELIST parameters needed for normal usage.	NAMELIST split by "basic" and "expert" so most users need to understand relatively few inputs.
4	Assure Fortran 77 Standard, independent of proprietary libraries and the non-portable "r8" compiler switch.	Done. Double precision available via the C-pre-processor, for example, "#define REAL real*8" in an "include" file.
5	Reduce sensitivity to computational parameters; generally improve performance.	One bug and one somewhat unreliable strategy found and removed.

LSC — 2000

What Next?

#	GOAL
1	Test further with TSC in real cases.
2	Integrate into TRANSP library.
3	Finish the LSC Manual.

"One bug and one somewhat unreliable strategy found and removed."

- BUG: Diffused power could sometime go negative.

  SOLUTION: Repair mistake in one Fortran statement.

- UNRELIABLE STRATEGY: The convergence of the distribution function and the power absorption was poor in some cases.

  SOLUTION: Greatly increase the number of iterations for better convergence.

  THANKS TO: Dr. Myunghee Ju, of KSTAR, now in Cadarache.

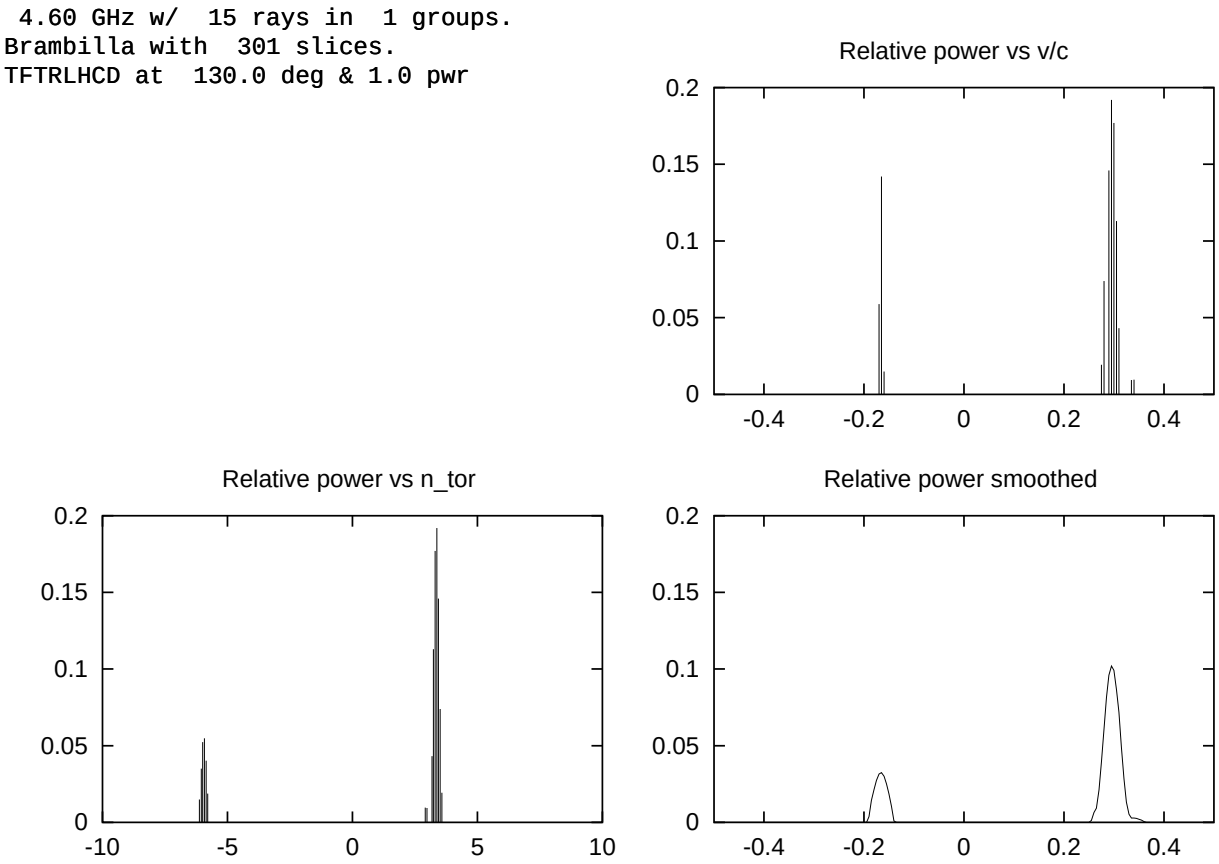
Typical Graphic Output

(This sheet and 4 following sheets)

LSC_24Sep00 inputs and parameters:

fghz	4.6000	couplers1	TFTRLHCD
HstpLH	0.0100	paseDeg-1	130.0000
nstep	20000	powers-1	1.0000
nrays	15	TurnNegs	0
ntors	15	Vmin	-1.0000
npols	1	Vmax	1.0000
nGrps	1	nfreq	50
npsi	100	lfast	0
nzones	2000	thet0unus	0.0000
nv	401	PPSI	401
nsmoo	9	PNX	125
nsmw	3	PNZ	159
nRampUp	200	PIMP	3
nFlat	10	PWORDS	10
idiag(1)	200	NPSIDIM	100
idiag(2)	0	NRAYDIM	210
WeghtItr	0.2000	NTORDIM	30
ScatKdeg	0.0000	NPOLDIM	7
DiffuJrf	0.0000	NVELDIM	401
PrfSpred	0.0000	NZONDIM	2000
DoTRAN	0	NPLTDIM	800
DoXcam	0	NGRPDIM	3
Do1Rpr	0		
Do0Edc	0		
DoBram	1		
nslices	301		
nGrps	1		

"Graphed" input parameters to LSC for keeping track of the nature of the calculation by putting important information in the graphics output file.

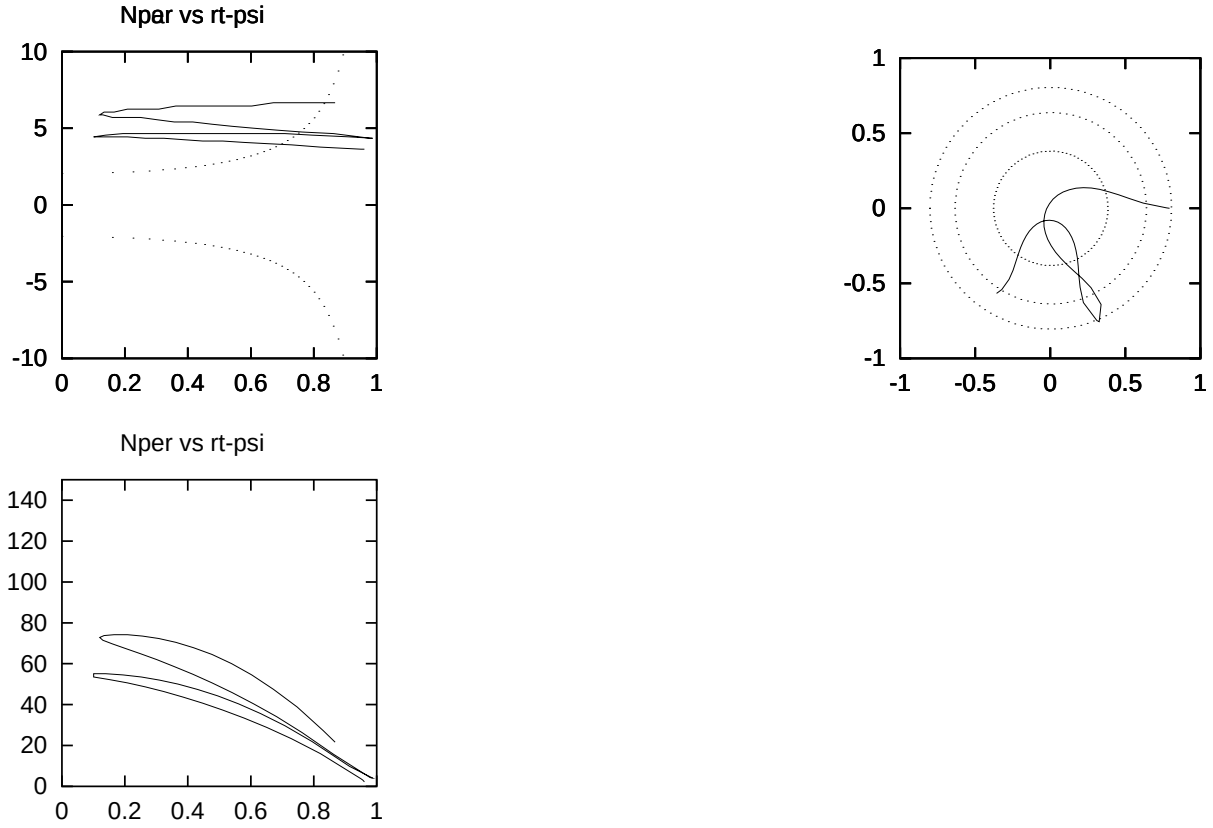


A launched spectrum from a Brambilla calculation, including the negative-going minor components.

Upper-right: Bar graph showing relative powers versus v/c .

Lower-left: Same, but represented versus n-parallel.

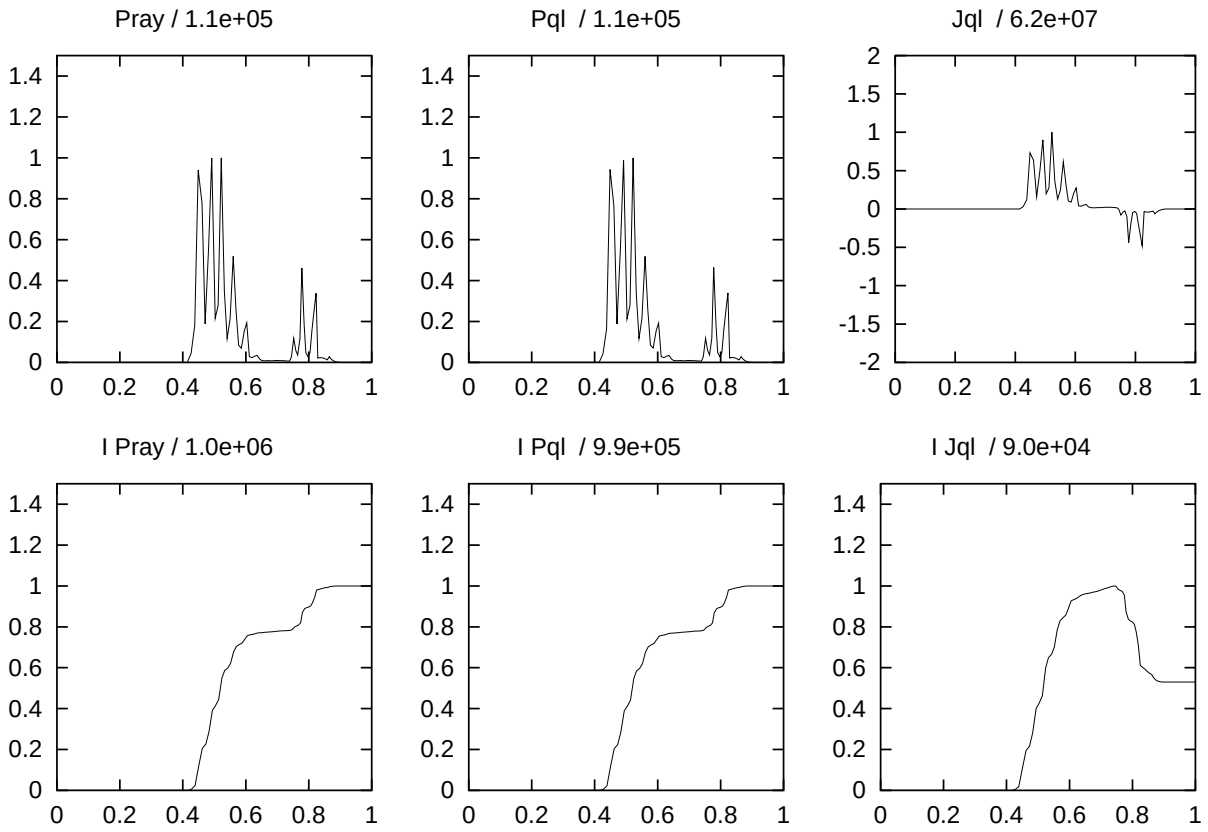
Lower-right: The launched spectrum as smoothed in velocity by the same smoothing function used in constructing the quasi-linear distribution function.



A typical result of the calculation for *one* ray.

Left side: Evolution of n-parallel (top) and n-perpendicular (bottom) versus square root of normalized poloidal flux. The dotted line on the top frame indicates the region of strong *linear* damping, ie, if the magnitude of n-parallel is larger than the magnitude shown dotted, then the linear damping is strong. Quasi-linear damping may not be strong, owing to quasi-linear burn-through.

Right side: Ray trajectory projected onto a poloidal cross section of the plasma. The "roundness" comes from an idealized test case; in general the cross section is elongated with the correct Shafranov shift of flux surfaces.

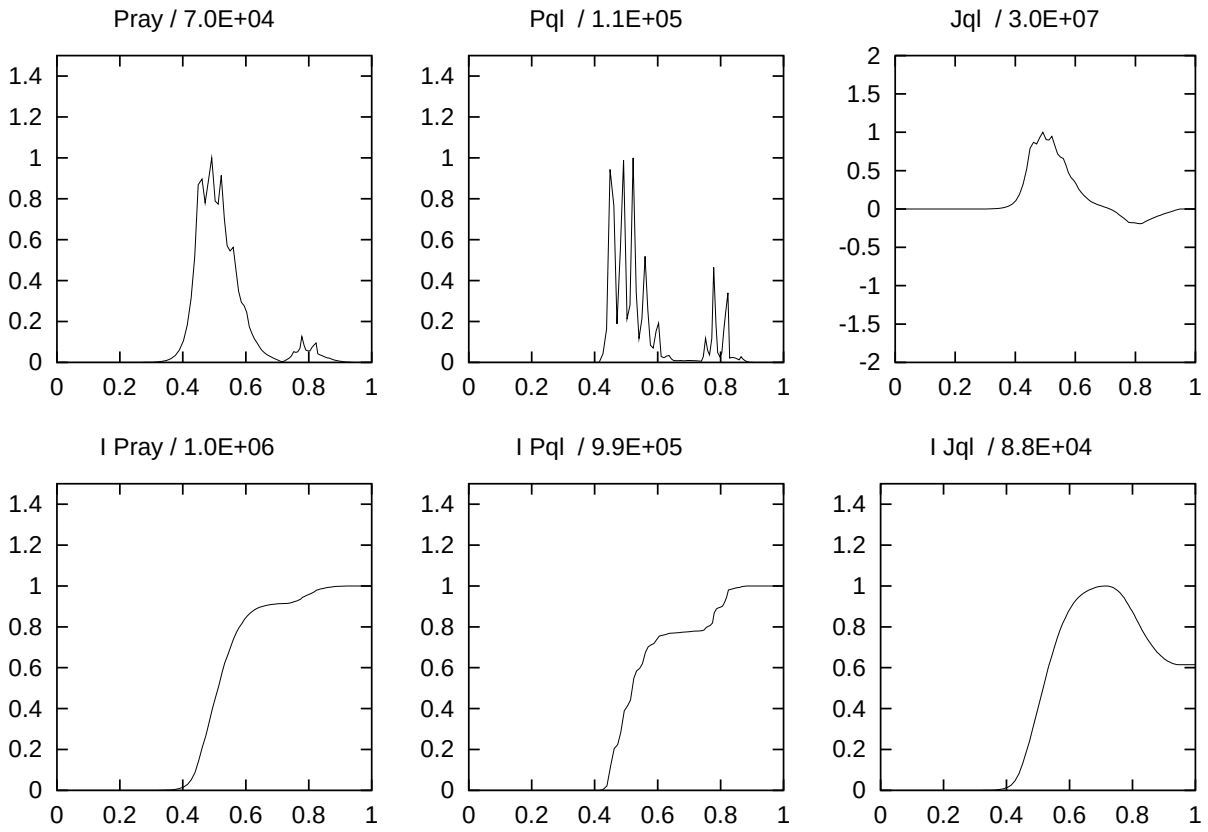


Power and current deposited *without diffusing* the current or the power. More rays would produce a smoother result. Horizontal axis is the square root of normalized poloidal flux.

Left two: Volumetric and integrated power from the ray point of view for 1 MW launched power.

Center two: As on left, but from the quasi-linear power deposition point of view.

Right two: Volumetric and integrated current. The negative current stems from negative-going components of a realistic launched spectrum.



Power and current deposited *with diffusing* the current and then the power.

The current diffusion coefficient was set to 0.05 meter-squared per second, and the weighting of the diffusion effect on the power was 90 percent.

Note that the center frames show un-diffused power.

Some Web Addresses

- http://w3.pppl.gov/~ignat
  The LSC Home Page. Links to code and documentation will, in general, be found here.
- http://w3.pppl.gov/topdac/lsc.htm
  The LSC Fact Sheet. Links to code and documentation will, in general, be found here.
- http://www.cs.dartmouth.edu/gnuplot_info.html
  The gnuplot Home Page. "Gnuplot is a command-line driven interactive function plotting utility for UNIX, MSDOS, and VMS platforms. The software is copyrighted but freely distributed..."
- http://w3.pppl.gov/NTCC
  The NTCC Home Page. "The goal of the National Transport Code Collaboration (NTCC) project is to bring about a change in the way fusion modeling codes are constructed and used in the fusion community..."
- http://w3.pppl.gov/topdac/
  The Toroidal Physics Design and Analysis Codes Home Page. "The TOPDAC system is a collection of scientific computer programs that calculate equilibrium, stability, transport, and other properties of tokamak plasmas..."
- http://w3.pppl.gov/topdac/tsc.htm
  The TSC Fact Sheet "TSC is the Tokamak Simulation Code developed at PPPL ... . It can model the evolution of a free-boundary axisymmetric tokamak plasma on several different time scales..."

- http://w3.pppl.gov/transp
  The Transp Home Page.
- http://w3.pppl.gov/topdac/transp.htm
  The TRANSP Fact Sheet "TRANSP is a system for time dependent 1 1/2 dimensional transport and confinement analysis and diagnostic simulation of tokamak data..."