Google:[Leonid Zakharov] $\longrightarrow$ http://w3.pppl.gov/~zakharov

LiWall Fusion and its 3 step R&D program

Leonid E. Zakharov

Princeton Plasma Physics Laboratory, MS-27 P.O. Box 451, Princeton NJ 08543-0451

FESAC Strategic Planning Panel,

August 07, 2007, PPPL, Princeton NJ

[1]This work is supported by US DoE contract No. DE–AC020–76–CHO–3073.

LiWF science vs BBBL-70s ("The Bib$_b$le of the 70s")

LiWF $\equiv$ NBI heating/fueling $+$ Lithium Pumping PFC. No cold particles except He. vskip1em

Issue	LiWF	Current BBBL-70s concept of "fusion"
The target	RDF (Reactor Dev.Facility, neutron source)	Political "Burning" plasma
Reactor Issues:	$P_{NBI} = E/\tau_E$	ignition criterion $f_{pk} p \tau_E = 1$?
Hot-α, 3.5 MeV	"let them go"	"confine them" ?
Cold-α, mixed with plasma	N/A	"let them go" ?
$P_\alpha = 1/5 P_{DT}$	goes to walls, Li jets	dumped to SOL ?
Power extraction from SOL	conventional technology	no idea except to "radiate 90 %" ?
Plasma heating	"hot-ion" mode: NBI $\longrightarrow i \longrightarrow e$	"hot-e mode": $\alpha \longrightarrow e \longrightarrow i$?
Use of plasma volume	100 %	25-30 %
Tritium control	pumping by Li	tritium in all channels and in dust ?
Plasma contamination	no Z^2 thermo-force drive, core fueling	junk from walls to the plasma ?
He pumping	as ionized gas, $p_{in} < p_{out}$	gasdynamic, $p_{in} > p_{out}$?
Fusion producing β_{DT}	$\beta_{DT} > 0.5\beta$	diluted: $\beta_{DT} < 0.5\beta$?
Physics:		
Confinement	diffusive, RTM$\equiv \chi_= \chi_e = D = \chi_i^{neo}$	turbulent thermo-conduction ?
Anomalous electrons	play no role	YES for 40 years and ahead ? ? ?
Transport database	scalable by RTM (Reference Transp. Model)	not scalable to "hot e"-mode ?
Sawteeth, IREs	absent	unpredictable ?
ELMs, $n_{Greenwald}$-limit	absent	intrinsic for low T_{edge} ?
p'_{edge} control	by RMP through n_{edge}	through $T_{edge} \longrightarrow$ low performance ?
Fueling	existing NBI technology	unresolvable ?
Fusion power control	existing NBI technology	no idea ?
Tangible RDF time scale:	$\Delta t \simeq 15$ years	$\partial_t(progress) \simeq 0,\ \Delta t \simeq \infty$
Cost:	\$2-2.5 B for RDF program	$\simeq$ \$20 B with no RDF strategy
Scientific status:	Consistent with physics and technology	Everything is Upside-Down

LiWF R&D relies exclusively on existing technology. It does not need fusion power ("burning plasma") until step 3

Steps toward RDF	Milestone	Priorities and Mission
NSTX with molten LLTP (Li Loaded Target Plate), B=0.4 T, $I_{pl}=1$ MA, A=1.2, $R_{outer}=1.5$ m	Reproduce T11-M, CDX-U, FTU plasma pumping experiments	Plasma pumping. Low energy NBI. Stability. Clarify the system compatibility with molten Li
ST0 (modified NSTX): B=0.3-0.5 T, I_{pl}=0.7-1 MA, A=1.2, $R_{outer}=1.5$ m. LTX (modified CDX-U) B=0.3 T, I_{pl}=0.3 MA, A=1.6, $R_{outer}\simeq 1.65$ m.	Achieve RTM-like confinement: $\tau_E \longrightarrow 2-3\times\tau_{E,NSTX}$.	Plasma boundary. Stability. Start-up. Core fueling by low energy NBI. Collisionless SOL/PFC interaction. Role of C-walls. Creating a design concept of LPD for ST1.
ST1: B=1.5 T, I_{pl}=2-4 MA, A $\simeq$ 5/3, $\beta=0.2-0.3$, $R_{outer}=1.65$ m	Achieve Super-critical regime: $Q_{DT}^{equiv}>5, \quad f_{pk}p\tau_E>1$	Plasma boundary. Stability. Physics and technology of LPD. Secondary electron emission. Role of TEM. Creating concept of a Startup and stationary LPD
ST2: DD-prototype of ST3, B=3 T, I_{pl}=4-8 MA, A $\simeq$ 5/3, $\beta=0.3-0.4$, $R_{outer}=2$ m, $Vol_{plasma}\simeq 30$ m^3	Achieve RDF stationary regime: $Q_{DT}^{equiv}=30-50$	High $\beta\simeq 30-40$ %. Noninductive current drive. Integrate the stationary plasma regime for RDF. Assess the feasibility of DD fusion.
ST3: DT neutron source. B=3 T, I_{pl}=4-8 MA, A $\simeq$ 5/3, $R_{outer}=2$ m, $Vol_{plasma}\simeq 30$ m^3	Achieve DT-stationary regime: $Q_{DT}=30-50,\ P_{DT}=0.2-0.5$ GW	Power extraction from α-particles, He exhaust. Integrate the stationary neutron producing regime for RDF mission.

PPPL has everything for initiation of LiWF and for ST1,ST2 steps

LiWF needs FESAC assistance to make just motivational steps

After this LiWF will bootstrap its program and funding