Validation of H-H_2O at Elevated Temperatures using Diffusion Experiments

Mike Zerkle
Jesse Holmes

Cross Section Evaluation Working Group

Brookhaven National Laboratory

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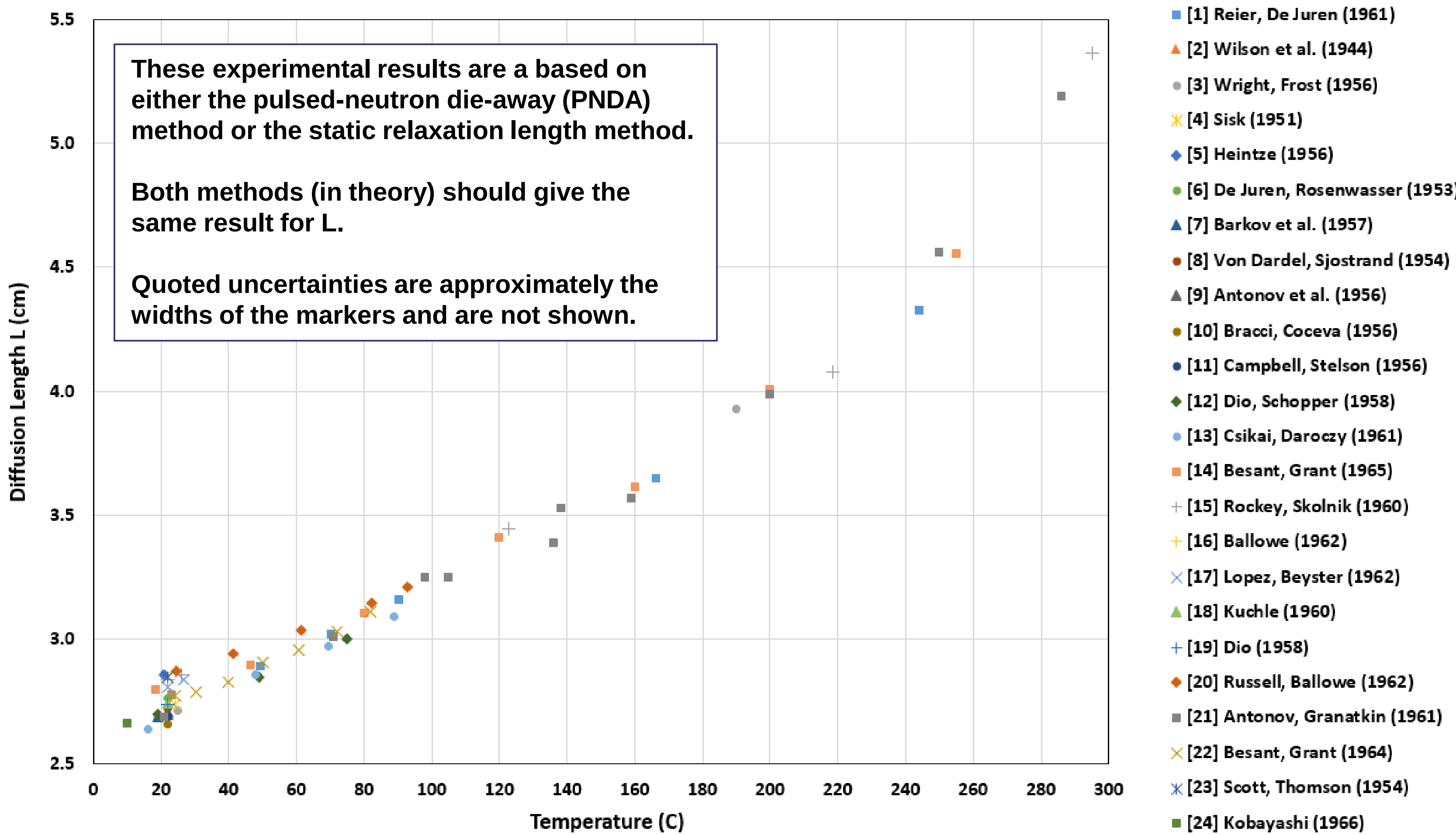
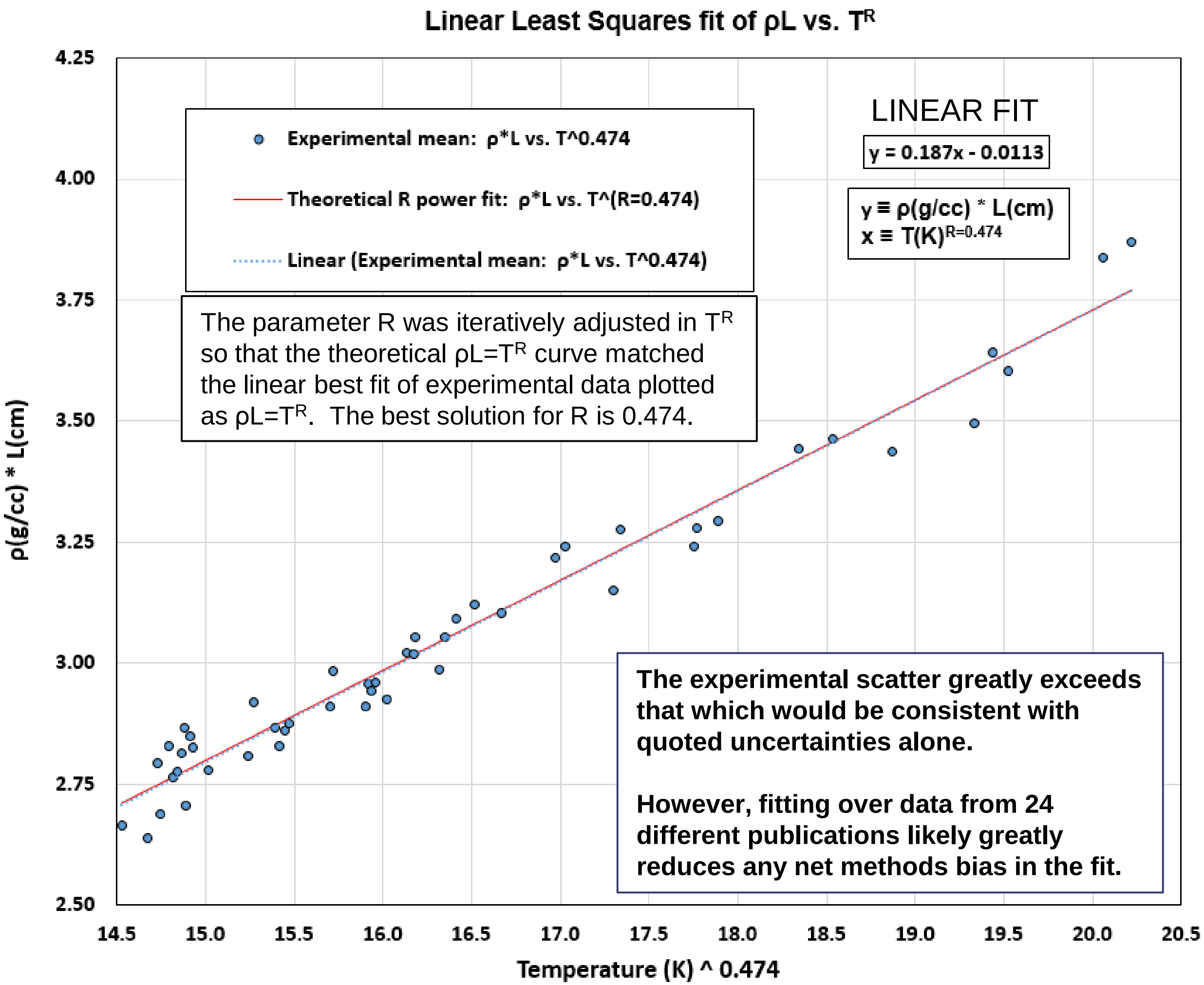
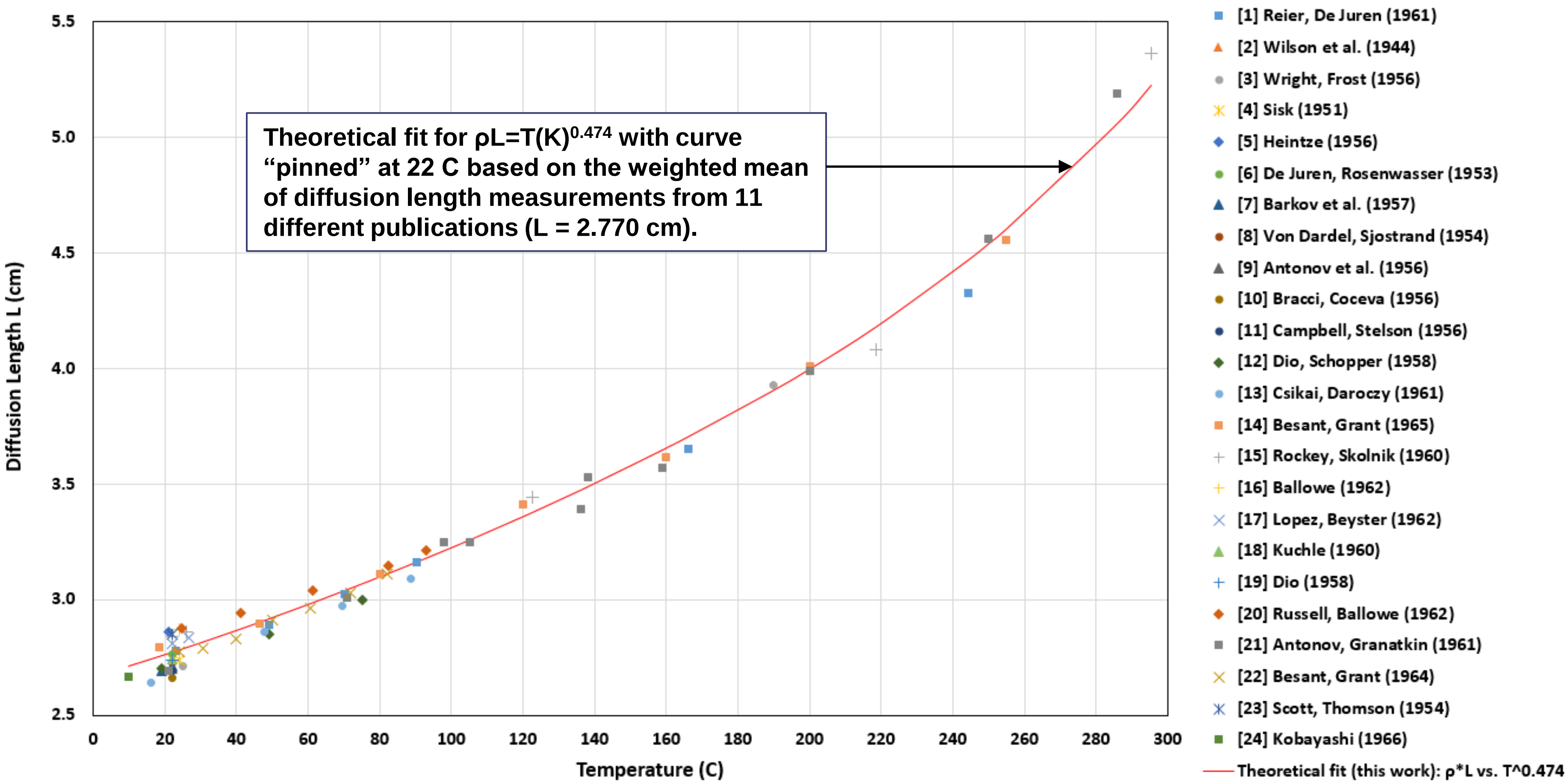
Compilation of Historical Thermal Neutron Diffusion Length (L) Measurements for Water



Linear and Power Fit Based on 24 Publications



Experimental Data Compared to Power Fit



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Calculating L with MC21 PNDA Simulations

- PNDA flux decay: $\varphi(\boldsymbol{r},t) = \varphi_0(\boldsymbol{r})e^{-\alpha t}$; fundamental eigenvalue α computed with MC21 simulations
- $\alpha = v\Sigma_a + vDB_g^2 - CB_g^4 + O(B_g^6) \approx a_0 + D_0 x + Cx^2$ for $x = B_g^2$
- $L \approx \sqrt{\frac{D_0}{2a_0}\left(1 + \sqrt{1 + \frac{4a_0 C}{D_0^2}}\right)} \approx \sqrt{\frac{D_0}{a_0} + \frac{C}{D_0}} \approx \sqrt{\frac{D}{\Sigma_a}}$
- Geometric buckling for spheres: $B_g^2 = \left(\frac{\pi}{r+z}\right)^2$.
- z is approximately proportional to λ_{tr} and is computed at 22 C by Sjostrand (1977) for water spheres (with corrections for small geometries).
- λ_{tr} is approximately proportional to D, and $L \approx \sqrt{\frac{D}{\Sigma_a}}$.
- The ratio of L at an arbitrary temperature to L at 22 C can be computed from the previously given fit.
- The expected D, λ_{tr}, and z for any temperature can now be computed (accounting for density change), allowing B_g^2 to be determined for water spheres of arbitrary radii and temperature.
- **Finally, calculated α can be plotted vs. B_g^2 for many water spheres of varying radii, and then L can be computed by solving for the coefficients a_0, D_0, and C with a quadratic fit.**

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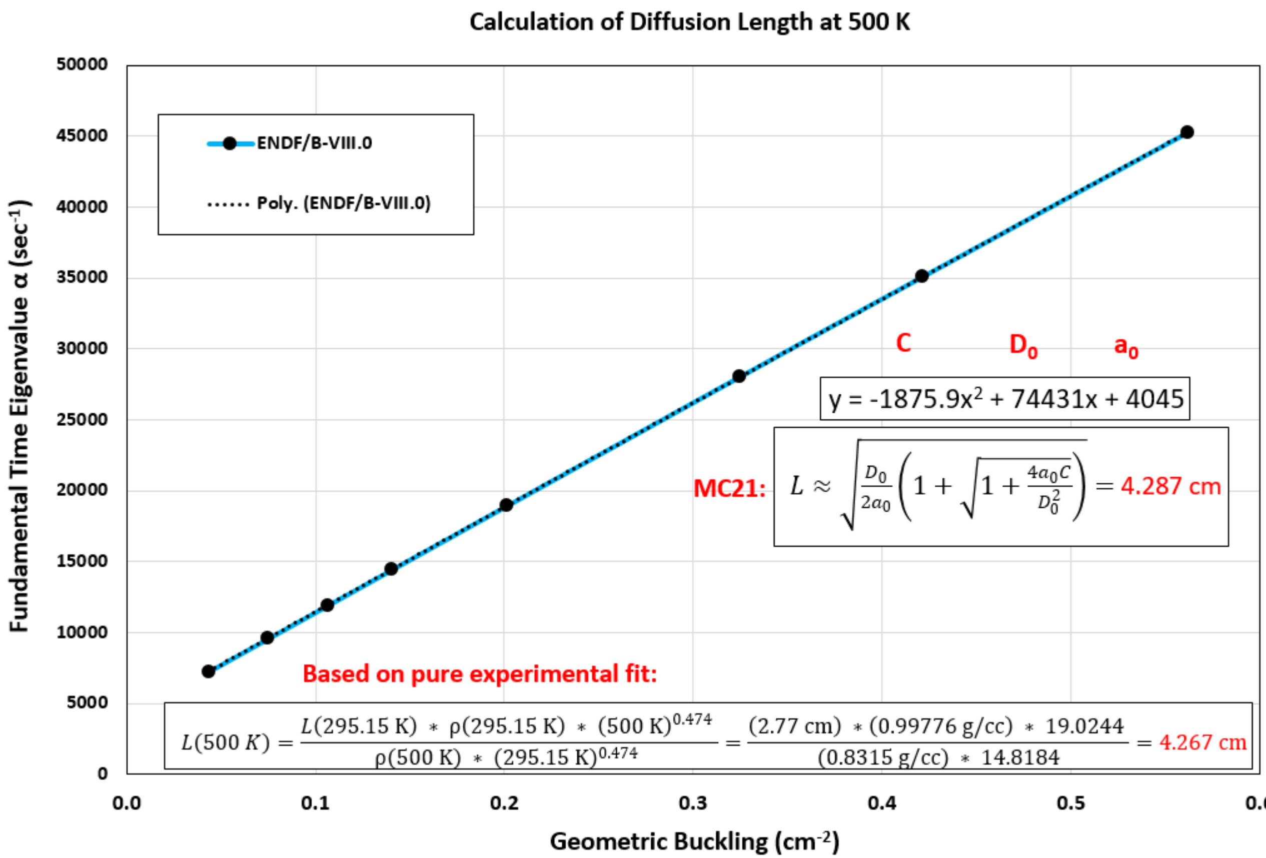
500 K MC21 Calculation Compared to Prediction by Pure Experimental Fit



Difference between MC21 result and pure experimental fit result for 500 K is 0.5%.

The uncertainty in MC21-calculated L due to ENDF uncertainty in $\sigma_a(^1H)$ is 0.9%.

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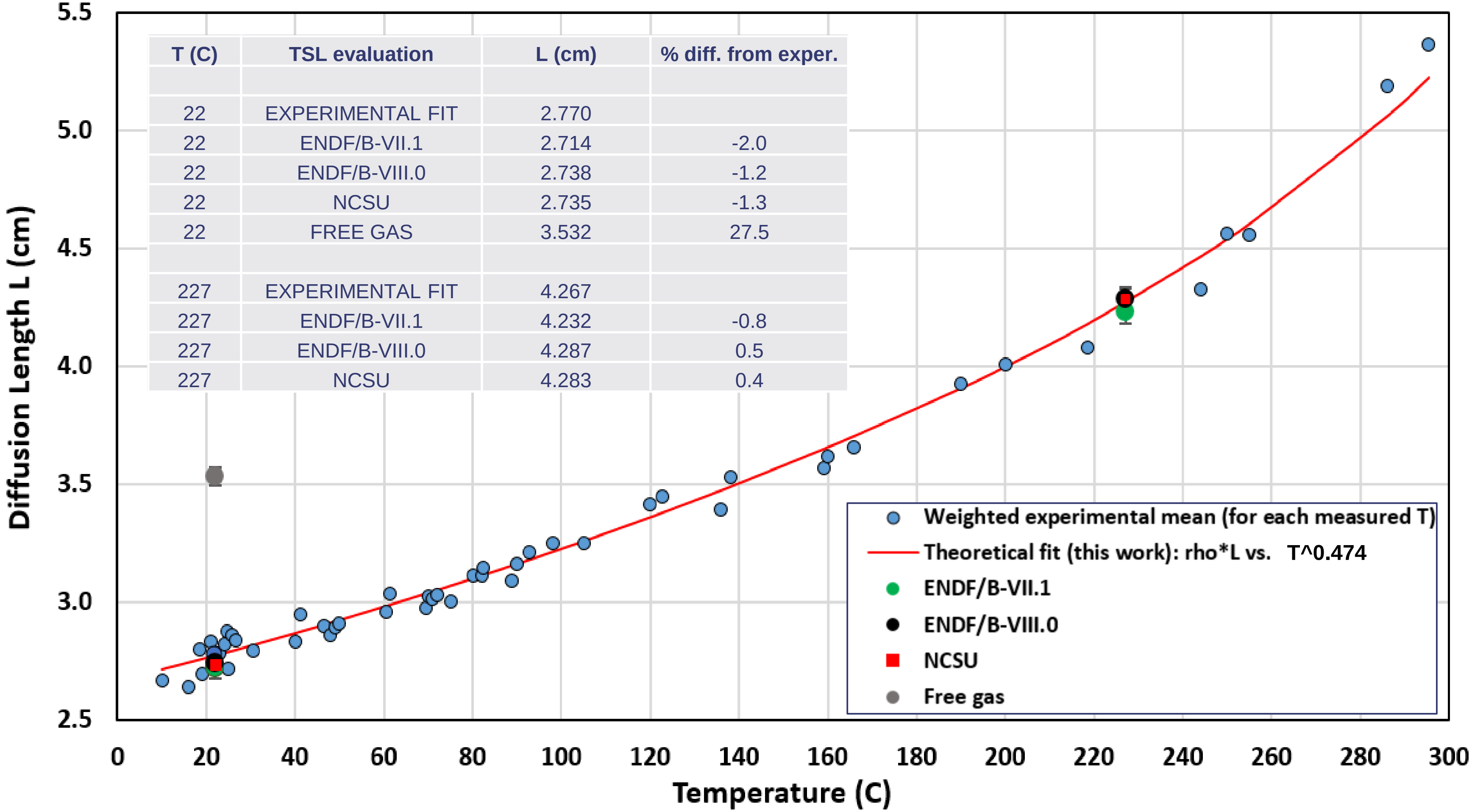
Room Temperature and 500 K Results for Several H-H_2O TSL Evaluations



T (C)	TSL evaluation	L (cm)	% diff. from exper.
22	EXPERIMENTAL FIT	2.770	
22	ENDF/B-VII.1	2.714	-2.0
22	ENDF/B-VIII.0	2.738	-1.2
22	NCSU	2.735	-1.3
22	FREE GAS	3.532	27.5
227	EXPERIMENTAL FIT	4.267	
227	ENDF/B-VII.1	4.232	-0.8
227	ENDF/B-VIII.0	4.287	0.5
227	NCSU	4.283	0.4

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