SUMMARY OF THE PROCEEDINGS OF
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THEORY OF THE LAMBDA TRANSITION

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Summary

A review is given on the status of the theory of the Lambda transition. Recent results of the Aachen theory group [1-5] on critical surface and finite size effects both in statics and dynamics are presented. It is pointed out that the critical heat capacity in a finite geometry depends sensitively on the boundary conditions. Quantitative results of a renormalization - group calculation of the specific heat in cylindrical [1] and plate geometry [4,5] for mesoscopic and macroscopic sizes are presented. Surface effects are shown to set in gradually already far from T_λ and are found to be more significant below T_λ than above T_λ. It is argued that accurate heat capacity experiments could probe sensitively the nature of the boundary conditions of the order parameter near solid walls. The thermal conductivity is discussed as the best candidate for testing the dynamic renormalization - group theory. Furthermore, theoretical results for the boundary contribution to the thermal resistance [3] are presented. Experiments in large samples under microgravity conditions would be needed to test the predicted bulk critical behavior closer to T_λ and to eliminate uncertainties in the interpretation of existing data. The present theory of the critical Kapitza resistance above T_λ [3] is in disagreement with recent measurements. Also below T_λ there are difficulties in comparing the theory with experiments on the Kapitza resistance because of contradictory experimental results. More accurate data are needed. It is proposed to perform measurements of the thermal resistance in the <u>same sample</u>

above and below T_λ and we recommend representing the total resistance by one continuous curve [2] extending from $T>T_\lambda$ to $T<T_\lambda$, with a finite value at T_λ. This value is determined by a finite size effect whereas the initial deviation from the bulk resistance away from T_λ can be interpreted as surface effects.

1. W. Huhn and V. Dohm, Phys. Rev. Lett. 61, 1268 (1988); W. Huhn, Dissertation, T.H. Aachen (1988)
2. V. Dohm, Z. Phys. B75, 109 (1989)
3. D. Frank and V. Dohm, Phys. Rev. Lett. 62, 1864 (1989); D. Frank, Dissertation, T.H. Aachen (1989)
4. A. Wacker and V. Dohm, to be published
5. R. Schmolke, V. Dohm, and D. Frank, to be published

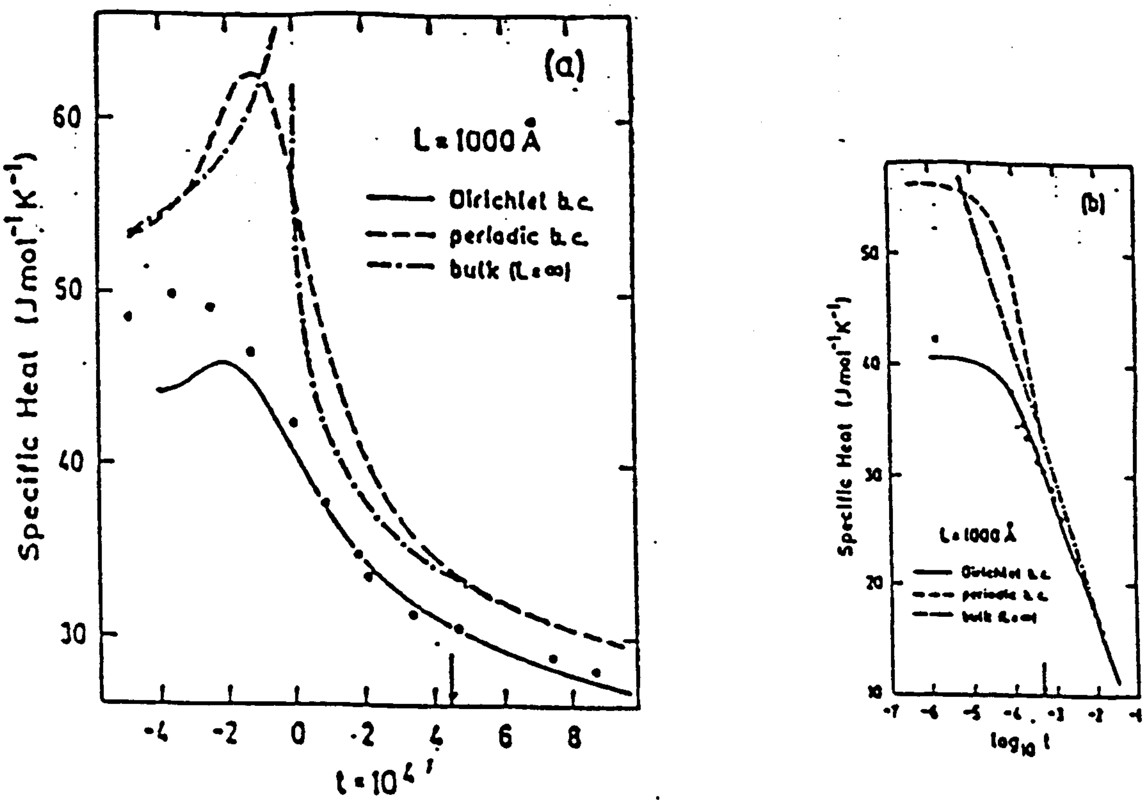
Statics

- Heat Capacity
  - Bulk
  - Surface
  - Finite Size

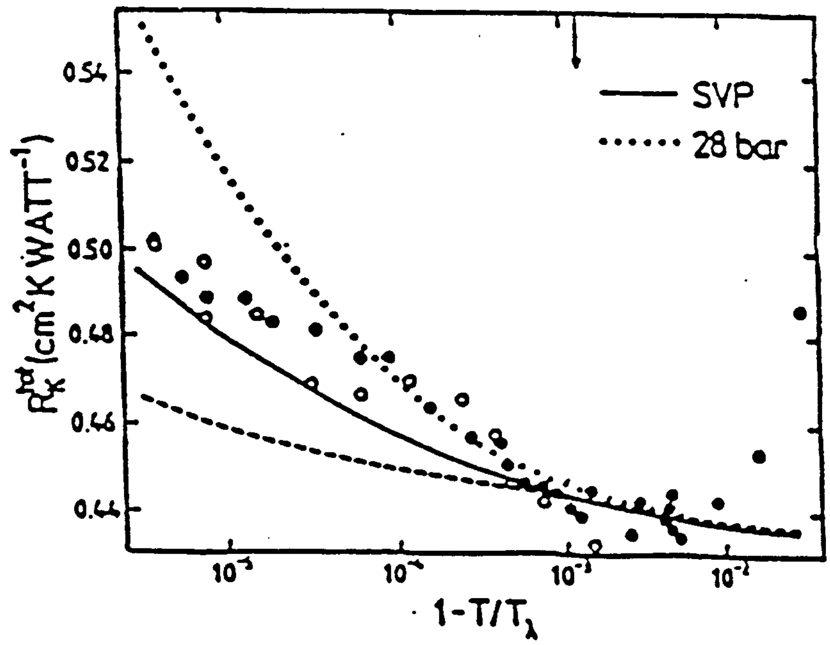
- Critical heat capacity of ^4He provides sensitive probe of boundary conditions between ^4He and solid surfaces. Critical fluctuations amplify the boundary effects. The following results by W. Huhn and V. Dohm, Phys. Rev. Lett. 61, 1368 ('88) show that $\psi = 0$ at solid walls is a fairly realistic boundary condition.

- There exists no sharp onset of finite-size effects, rather a gradual onset due to a surface effect induced by the $\psi = 0$ boundary conditions.

- This gradual deviation from bulk behavior sets in much earlier than expected. This is of relevance also for the interpretation of data under microgravity conditions in macroscopic geometries. Further measurements are needed.



Theoretical specific heat of confined ^{4}He (system size L = 1000 Å) vs t = $(T - T_\lambda)/T_\lambda$ and $\log_{10} t$ for Dirichlet boundary conditions (solid lines) and for periodic boundary conditions (dashed lines). Data (dots) from Ref. 3; dot-dashed lines (bulk specific heat) from Ref. 8. The arrows indicate the reduced rounding temperature t^*_{pbc}.



Kapitza resistance R_K^{tot} vs $(T_\lambda - T)/T_\lambda$. The solid line is our theoretical result; the dashed line represents the "hydrodynamic" result; both lines and the data are for saturated vapor pressure. The dotted line is our prediction for 28 bars. The arrow indicates the temperature at which R_K^o has been adjusted.

- Heat Conductivity
  - Bulk
  - Surface
  - Finite Size

- Critical thermal resistance of ^{4}He provides an interesting test of the dynamic RG theory.

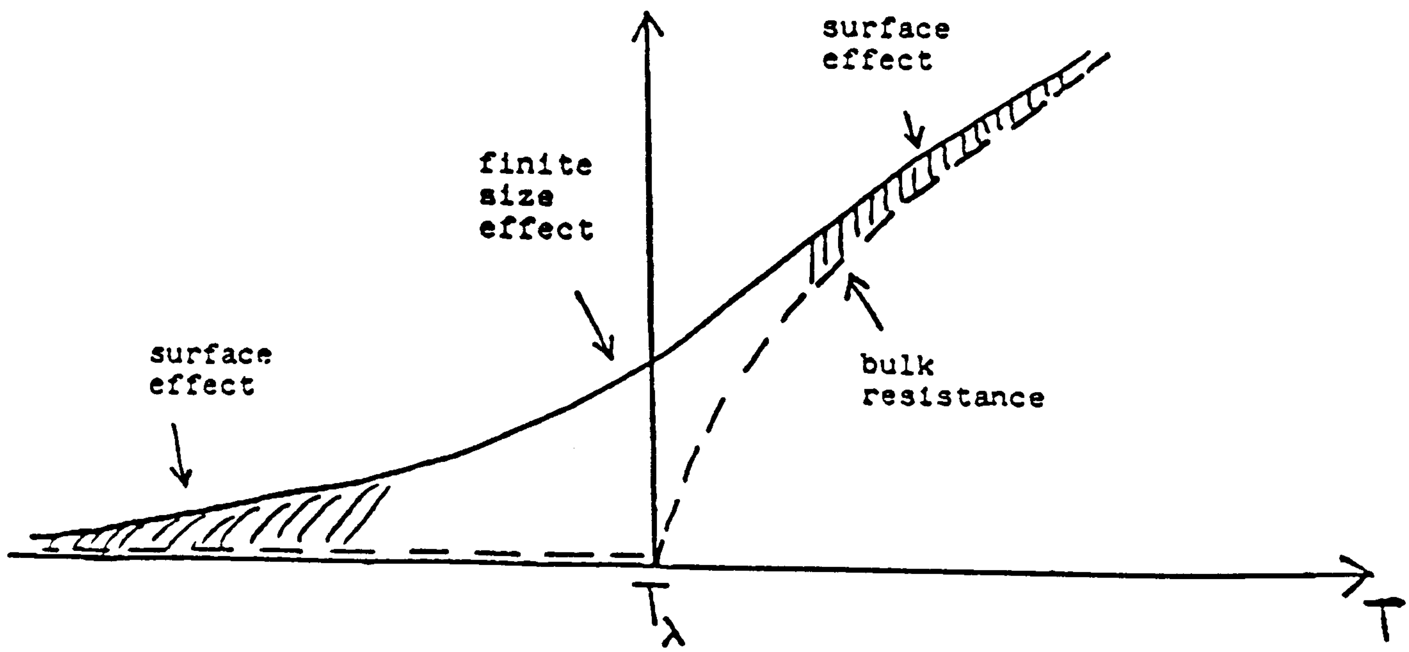
- Reliable measurements are not possible without knowledge of the Kapitza resistance R_k above and below T_λ.

- The RG theory by D. Frank and V. Dohm, Phys. Rev. Lett. 62, 1864 ('89) explains recent measurements of R_k below T_λ.

- More accurate data are needed. In particular above T_λ the effect of R_k requires further investigation.

- The total boundary resistance R_k is decomposed as $R_k = R_k^s + R_k^o$.

- The critical contributions R_k^s above and below T_λ should not be considered as separate quantities. Rather, the total ^{4}He thermal resistance should be plotted as one continuous curve through T_λ :



- The initial divergence of R_k^s will become rounded and finite at T_λ due to finite-size effect.