

Lists

F.1 Nomenclature

In the following subsections the symbols used in this thesis are given, with their dimensions if applicable, followed by a short description.

F.1.1 Symbols

A	-	critical power-law amplitude for the isochoric specific heat
A	$\text{K}\cdot\text{W}^{-1}$	apparent amplitude (see section 2.2.2)
B	-	critical power-law amplitude for the asymptotic shape of the coexistence curve
c_x	$\text{J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$	specific heat at constant x
d	-	dimensionality of the system
D	-	critical power-law amplitude for the variation of the pressure with density along the critical isotherm
D_c	m	diameter of a cylinder (see section 5.3)
D_m	m	diameter of the circular marker (see section 5.3)
D_T	$\text{m}^2\cdot\text{s}^{-1}$	thermal diffusivity
E	$\text{s}^{-1/2}$	system dependent constant (see section 2.3.2)
F	m	distance between image plane and film plane (see section 4.3.1)
g	$\text{m}\cdot\text{s}^{-2}$	acceleration of gravity
g_n	m^{-1}	average gradient (see section 4.3.1)
G	$\text{s}^{-1/2}$	system dependent constant (see section 2.3.1)
h	m	height
I	-	normalized temperature integral (see section 2.3)
j	$\text{W}\cdot\text{m}^{-2}$	heat flux
k	-	interference order

K_y	$\text{m}^2 \cdot \text{N}^{-1}$	compressibility at constant y
K_1	$\text{mol} \cdot \text{m}^{-4}$	fluid dependent parameter (see section 4.3.2)
K_2	$\text{mol} \cdot \text{m}^{-5}$	optics dependent parameter (see section 4.3.2)
L	m	path length of light in the sample
M	$\text{kg} \cdot \text{mol}^{-1}$	molar mass
M'	-	linear magnification (see section 4.3.1)
M	-	linear magnification in the film plane (see section 4.3.1)
n	-	refractive index
N	-	angular magnification (see section 4.3.1)
p	$\text{N} \cdot \text{m}^{-2}$	pressure
P	W	power
P	-	reduced meniscus position (see section 5.3)
P_m	-	reduced meniscus position (see section 5.3)
q	W	generated heat
q_f	W	heat flow into the fluid (see section 2.2.2)
q_l	W	heat losses to the cell walls (see section 2.2.2)
Q	J	amount of heat
Q	$\text{m}^3 \cdot \text{kg}^{-1}$	Lorentz-Lorenz constant (see section 5.1)
Q_0	-	system dependent constant in the power-law description for the viscosity
R_a	-	Rayleigh number
R_D	-	universal amplitude (see section 2.1.3)
s	$\text{J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$	entropy
S	m^2	surface area
t	s	time
t_c	s	characteristic time for isentropic equilibration (see section 2.2.2)
t_m	s	time after which the behaviour of the 'shadow' changes from type II into type I (see section 4.3.2)
T	K	temperature
T_{set}	K	set temperature of the thermostat (see section 3.1.2)
v	$\text{m}^3 \cdot \text{mol}^{-1}$	molar volume
V	m^3	fixed volume
x	m	spatial coordinate (in interferometry along the optical axis)
y	m	spatial coordinate (in interferometry perpendicular to the optical axis and parallel to the surface of the heater)
z	m	spatial coordinate along the direction of gravity (in interferometry perpendicular to the optical axis and to the surface of the heater)
Z_0	m	maximum size of the 'shadow' (see section 4.3.2)
\tilde{x}		reduced value of x
\bar{x}		Laplace transformed value of x
\hat{x}		difference from the initial value of x
x^*		reduced value of x
$\langle x \rangle$		average value of x

F.1.2 Greek symbols

α	-	critical power-law exponent
α_z	K^{-1}	thermal expansion coefficient at constant z
β	-	critical power-law exponent
γ	-	critical power-law exponent
Γ	-	critical power-law amplitude for the isothermal compressibility
δ	-	critical power-law exponent
Δ_T	-	reduced temperature lag (see section 2.3.1)
Δ_ρ	-	reduced excess density (see section 2.3.2)
ζ	-	critical power-law exponent
η	$N \cdot s \cdot m^{-2}$	viscosity
ϑ	rad	angle between light ray and heater surface (see section 4.2.2)
λ	$W \cdot m^{-1} \cdot K^{-1}$	thermal conductivity
Λ	m	laser light wavelength
μ	-	parameter (see section 2.3.1)
ν	-	critical power-law exponent
ξ	m	correlation length
ξ_0	m	critical power-law amplitude for the correlation length
ρ	$mol \cdot m^{-3}$	density
ρ_{CM}	$mol \cdot m^{-3}$	average of ρ_l and ρ_v - rule of Cailletet-Mathias (see section 5.3)
ρ_l	$mol \cdot m^{-3}$	liquid density
ρ_v	$mol \cdot m^{-3}$	vapour density
σ	-	thermal impedance ratio of a wall and the fluid (see section 2.2.2)
τ	-	reduced temperature difference
ϕ	-	reduced density difference
ψ	-	reduced pressure difference

F.1.3 Indices

a	apparent value (see section 6.2.3)
b	in the bulk of the fluid
c	critical value
eff	effective value
f	of the fluid
h	of the heater
i	of the i th wall
p	at constant pressure
s	at constant entropy
tot	the sum of all values
T	at constant temperature
v	at constant volume
w	of the wall

F.2 List of acronyms

AE	Adiabatic Effect
BPE	Bottom Peltier Element
BPL	Base Plate
CP	Critical Point
CPF	Critical Point Facility
CRESCENDO	Center for Remote SCIENCE ENhancement by DUC Operations
CSS	Current Source System
DHS	Data Handling System
DUC	Dutch Utilization Center
EDE	Experiment Dedicated Equipment
EGSE	Electrical Ground Support Equipment
EOS	Equation of State
EPT	Experiment Parameter Table
ESA	European Space Agency
HEX	Heat Exchanger
IF	Interferometry
IFU	Interferometer Unit
IML-2	International Microgravity Laboratory #2
LDC	Linear Diode Camera
LED	Light Emitting Diode
NASA	National Aeronautics & Space Administration
NLR	Nationaal Lucht- en Ruimtevaartlaboratorium (National Aerospace Laboratory)
OIO	Optical Input and Output system
OTS	Outer Thermal Shield
PA	Parabolic Approximation
PCB	Printed Circuit Board
PE	Piston Effect
PMT	Photo Multiplier Tube
PWM	PulseWidth Modulated
SALS	Small Angle Light Scattering
SAMS	Space Acceleration Measurement System
SC	Sample Cell
SCU	Sample Cell Unit
SCUm	Sample Cell Unit monitoring thermistor
SCUr	Sample Cell Unit regulating thermistor
TCS	Thermal Control System
THU	Thermostat Unit
TNO	Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek
TNO TPD	TNO Technisch Fysische Dienst
TPE	Top Peltier Element
TPL	Top Plate
VSS	Voltage Source System

VWZI	Van der Waals-Zeeman Instituut
WALS	Wide Angle Light Scattering

F.3 List of tables

Table 2.1	Universal critical exponents. <i>page 10</i>
Table 3.1	List of optical components. <i>page 31</i>
Table 5.1	Critical values for SF ₆ . <i>page 56</i>
Table 5.2	Experimental results. <i>page 60</i>
Table 6.1	Inverse thermal impedance and surface area of wall materials. <i>page 71</i>
Table 6.2	Measured thermal diffusivities. <i>page 80</i>
Table 6.3	Measured values of $(-\rho\alpha_s)$. <i>page 86</i>
Table E.1	Optical layout for the CPF. <i>page 111</i>
Table E.2	CPF Optical diagnostic methods. <i>page 112</i>

F.4 List of figures

Figure 1.1	The (P,T) Phase Diagram. <i>page 2</i>
Figure 2.1	Illustration of the density-temperature phase diagram. <i>page 9</i>
Figure 2.2	The temperature profile after the onset of heating. <i>page 13</i>
Figure 2.3	Temperature profile at the heater. <i>page 17</i>
Figure 2.4	Temperature change near a 'cold' wall. <i>page 19</i>
Figure 2.5	I as a function of μ . <i>page 21</i>
Figure 2.6	Density change near a 'cold' wall. <i>page 21</i>
Figure 2.7	The critical dependence of E. <i>page 23</i>
Figure 2.8	Gravity induced density gradients. <i>page 24</i>
Figure 3.1	A simplified cross-section of the THU and HEX. <i>page 28</i>
Figure 3.2	CPF thermostat and optical system block diagram. <i>page 30</i>
Figure 3.3	THU and ground optical arrangement. <i>page 35</i>
Figure 3.4	The optical set up for the IFU. <i>page 36</i>
Figure 3.5	Schematic of the interferometry chamber. <i>page 38</i>
Figure 3.6	Top view of the scattering chamber including the arrangement of the WALS optical fibres. <i>page 39</i>
Figure 3.7	The Spaceflight SCU. <i>page 40</i>
Figure 3.8	The density-refractive index SCU. <i>page 41</i>
Figure 4.1	An example of an interferogram. <i>page 44</i>
Figure 4.2	Geometry of a light ray passing through an optically inhomogeneous sample. <i>page 45</i>
Figure 4.3	Gravity induced deviation of a beam of light in a critical sample at various temperatures; the dashed line indicates the level at which $\rho=\rho_c$ (the meniscus). <i>page 46</i>
Figure 4.4	Schematic representation of the path of a ray through the sample. <i>page 47</i>
Figure 4.5	Schematic representation of the path of rays through the sample and the optics to the image plane and camera-film. <i>page 49</i>
Figure 4.6	An example of a shadow adjacent to the heater. <i>page 50</i>
Figure 4.7	Deviations w.r.t. to a parallel beam of a beam passing through a density field following heating at one side. <i>page 51</i>
Figure 4.8	Z0 and <i>tm</i> versus the distance to <i>Tc</i> for SF ₆ and CPF-optics. <i>page 53</i>

- Figure 4.9 z in time for various temperatures. *page 54*
- Figure 5.1 Density vs meniscus position. *page 61*
- Figure 5.2 Density vs meniscus position. *page 61*
- Figure 5.3 P_m at T_c -110 mK vs P_m at T_c -30 mK. *page 62*
- Figure 5.4 A unified plot of ρc versus P_m . *page 63*
- Figure 5.5 Refractive index (n) vs density (ρ). *page 63*
- Figure 6.1 WALS at 22° , 30° and 38° during crossing of T_c . Each curve is labelled by its corresponding fibre. *page 66*
- Figure 6.2 Coexisting phases at 10 mK below T_c in μg visualized. *page 67*
- Figure 6.3 Schematic display of heat flows during heating with the plate heater. *page 67*
- Figure 6.4 Interferometry fringes (a) before heating ($t=0$ s), and (b) at time $t=57$ s after the onset of heating. *page 68*
- Figure 6.5 Fraction of total delivered energy that enters the heater substrate. *page 70*
- Figure 6.6 Comparison between the inverse thermal impedance of the fluid and the wall materials. *page 73*
- Figure 6.7 Variation of the characteristic time, t_c , with the distance to T_c . *page 73*
- Figure 6.8 Theoretical predictions of isentropic temperature rise in our sample fluid accounting for heat losses to the heater substrate and through the other surrounding walls. *page 74*
- Figure 6.9 Thermistor readings relatively far from CP during heat pulses of constant power and predictions by eqs. (2.34), (2.36) and (2.37). *page 75*
- Figure 6.10 Thermistor readings relatively close to CP during heat pulses of constant power and predictions by eqs. (2.34), (2.36) and (2.37). *page 76*
- Figure 6.11 Experimental data of isentropic temperature rise per Watt of dissipated power at several times during heating runs versus the distance to T_c . *page 77*
- Figure 6.12 Comparison between predictions and experiment as regards the amplitude A . *page 77*
- Figure 6.13 Shadow front movement in the PA. *page 79*
- Figure 6.14 The shadow front close to T_c . *page 81*
- Figure 6.15 The shadow front far from T_c . *page 82*
- Figure 6.16 The thermal diffusivity versus temperature difference to T_c . In the middle the temperature ranges studied by the various authors are indicated. *page 83*
- Figure 6.17 A sketch of the density change versus the simultaneously measured temperature change during local heating. *page 85*
- Figure 6.18 Measurements of bulk temperature and density changes. *page 87*
- Figure 6.19 A plot of $\langle \rho(t) \rangle$ versus $Tb(t)(1+E\sqrt{t})$. *page 88*
- Figure 6.20 A double logarithmic plot of cv versus $T-T_c$. *page 89*
- Figure 6.21 Illustration of the isentropic character of the T - ρ response and its break down due to gravity jitter. The dashed vertical line indicates the start of the gravity jitter. The actual size of the disturbance in the gravity level is displayed in the upper part. *page 90*
- Figure B.1 R within x_{eff} . *page 99*
- Figure B.2 R at $x=0$. *page 99*
- Figure E.1 C_1 vs temperature for two different power densities. *page 106*
- Figure E.2 A contour plot of C_2 . *page 107*
- Figure E.3 C_1 and C_2 in time for z at various temperatures. *page 108*
- Figure E.4 Schematic representation of the real path of a ray through the fluid compared to the path in the PA. *page 109*
- Figure E.5 A contour plot of $\Delta z'/z'PA$ versus z and t . *page 110*
- Figure E.6 The effect of the departure from the PA to z in time. *page 111*