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# SLIDE #1: INTRODUCTION/ABSTRACT

## CHMT 2019 CRYOGENIC HEAT AND MASS TRANSFER

Traditionally heat and mass transfer (within NEWTONIAN domain ambit) is linearly proportional to its parametric state at any instance in time.. "*in which the viscous stresses arising from its flow at every point are ((**linearly**)) proportional to the local strain rate* ". [ACCENT LINEARLY] Because viscosity and strain becomes disjointed (NON-NEWTONIAN FLUID) in the saturation zone (which becomes grossly compounded in the cryogenic zone because of crystalline and molecular transformations and finite thermal gradients proximal to the ABS ZERO zone, traditional heat (and mass) transfer becomes convoluted and (CRYOGENIC) heat/mass transfer methodologies (and algorithms thereto) must be reincarnated. Therefore given *((**nonlinear**))* character of heat and mass transfer (inclusive BOLTZMAN black-bulb radiation) in the cryogenic zone, the route to rational means to end is non-linear (Joukowski) transformation of the linear equation sets and solving the CRYOGENIC) problem in the imaginary zone.

Proposed presentation/contribution will focus on "HYPERSONIC STOCHASTIC SWITCH" (poster subject material of TWENTE July, 2014) whereby LINEAR NEWTONIAN tensors are transformed into (perfectly normally random) stochastic/harmonic (spinning) vortex flux. Quest #2 will be developing/postulating a secondary (subsonic) switch to excite the cryogenic zone into computationally responsive tensor grid.

***FOOTNOTE: The July, 2014 TWENTE (RANDOMNESS) and March, 2016 DELHI (HYPERSONIC CRYOGENICS) presentations as well as EUCAS2017 (GENEVA) and EUCAS2019 (GLASGOW) is being inferred by reference are being incorporated by reference; (www.constellationd.com and www.constellation.com/eucas2019/)***

# EXTREME NUCLEATE HEAT TRANSFER IN THE CRYOGENIC ZONE, CHMT2019 (TWENTE, NL)

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## SLIDE #2: FORSTER-ZUBER BOILING TRANSFER COEFF (1955)

$$h_{nb} = 0.00122 \frac{k_L^{0.79} C_{P,L}^{0.45} \rho_L^{0.49} g_c^{0.25} \Delta T_e^{0.24} \Delta P_{sat}^{0.75}}{\sigma^{0.5} \mu_L^{0.29} \lambda^{0.24} \rho_V^{0.24}}$$

**h/nb=0.00122x(k/L^0.79xCP/L^0.45xρ/L^0.49xg/c^0.25xΔT/c^0.24XΔP/sat^0.75)//(σ^0.5xμ/L^0.29xλ0.24ρ/V^0.24**

()

where;

$h_{nb}$ = nucleate boiling heat-transfer coefficient, Btu/h · ft$^2$ · °F(W/m$^2$ · K)

$k_L$ = liquid thermal conductivity, Btu/h · ft · °F (W/m·$K$)

$C_{P,L}$ = liquid heat capacity, Btu/lbm · °F(J/kg · K)

$\rho_L$ = liquid density, lbm/ft$^3$ (kg/m$^3$)

$\mu_L$ = liquid viscosity, lbm/ft · h(kg/m · s)

σ = surface tension, lbf/ft(N/m)

$\rho_V$ = vapor density, lbm/ft$^3$ (kg/m$^3$)

λ = latent heat of vaporization, Btu/lbm (J/kg)

$g_c$ = unit conversion factor = 4.17 × 10$^8$ lbm · ft/lbf · h$^2$ (1.0 kg · m/N · s$^2$)

$\Delta T_e = (T_w - T_{sat}),$ °F(K)

$T_w$ = tube-wall temperature, °F(K)

$T_{sat}$ = saturation temperature at system pressure, °F(K)

$\Delta P_{sat} = P_{sat}(T_w) - P_{sat}(T_{sat})$, lbf/ft$^2$ (Pa)

$P_{sat}(T)$ = vapor pressure of fluid at temperature $T$, lbf/ft$^2$ (Pa)

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# SLIDE #3: COMPLEX FORSTER-ZUBER TRANSFORMATION

$$h_{nb} = 0.00122 \frac{k_L^{0.79} C_{P,L}^{0.45} \rho_L^{0.49} g_c^{0.25} \Delta T_c^{0.24} \Delta P_{sat}^{0.75}}{\sigma^{0.5} \mu_L^{0.29} \lambda^{0.24} \rho_V^{0.24}}$$

**i h/nb =**

**0.00122x (k/L^0.79 x CP/L^0.45 x ρ/L^0.49 x g/c^0.25 x**

**i1 ΔTc^0.24 x i2 ΔP/sat^0.75) //**

**(σ^0.5 x μ/L^0.29 x K^0.24 x ρ/V^0.24)**

i = Stochastic/Random (COMPLEX) Transformation
i1 = Complex temperature enumeration
i2 = Complex Temperature enumeration

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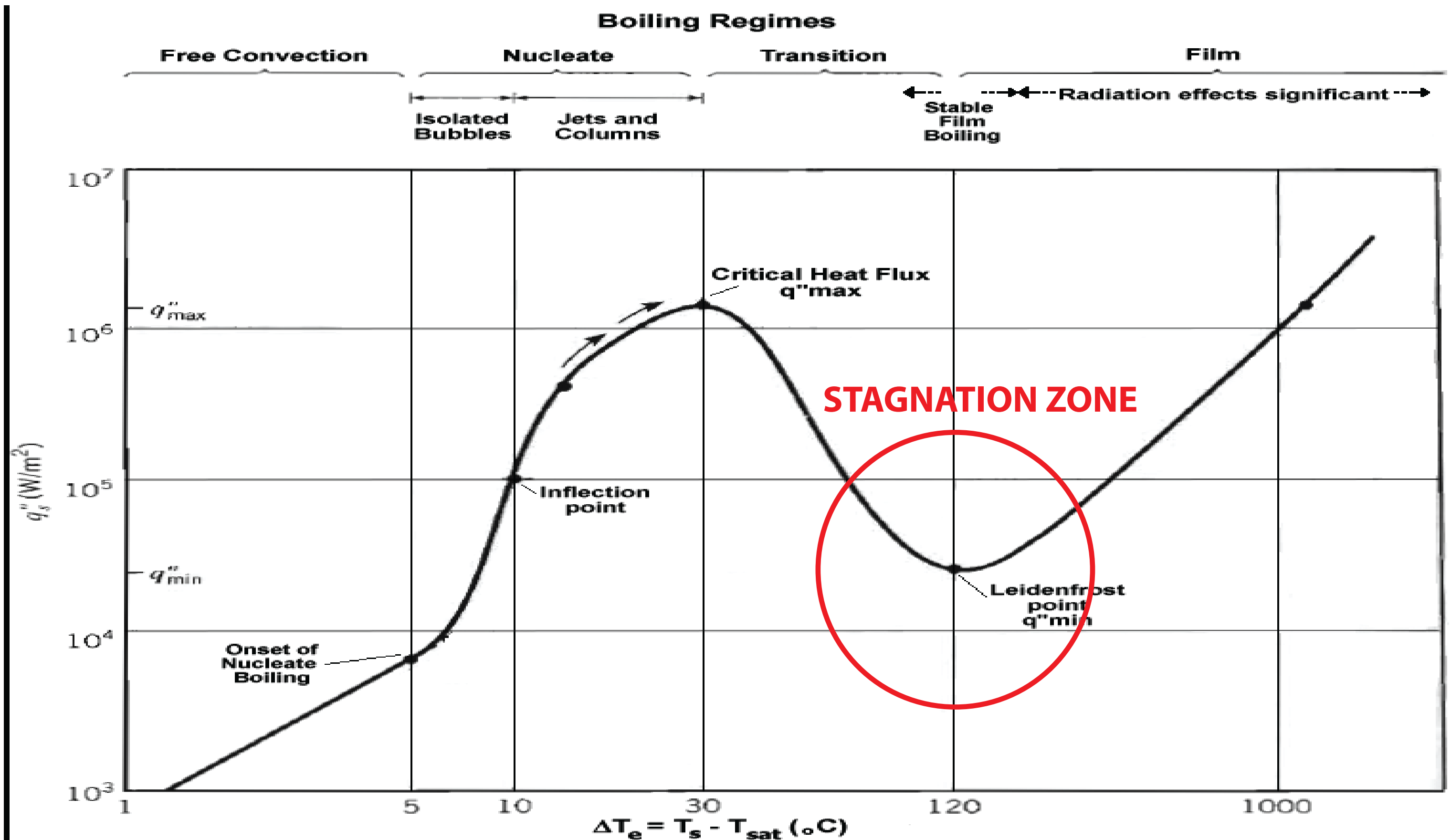
# SLIDE #4: ROSENSHAW BOILING CURVE (H2O)




Boiling Curve for water at 1 atm.
Surface heat flux q" as a function of excess temperature $\Delta T_e = T_s - T_{sat}$

# EXTREME NUCLEATE HEAT TRANSFER IN THE CRYOGENIC ZONE, CHMT2019 (TWENTE, NL)

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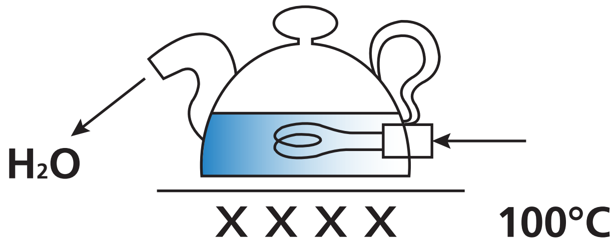
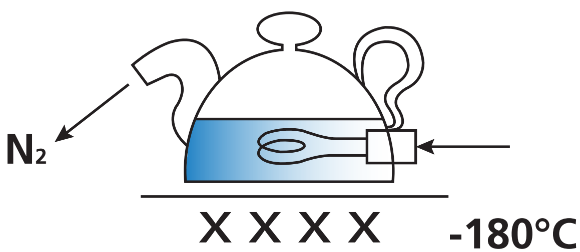
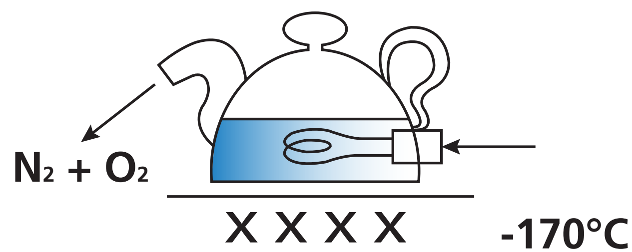
## SLIDE #5:CRYOGENIC KETTLE CORROLARY




**1. KETTLE + H2O**




**2. KETTLE + LN2 + LH2/O2**

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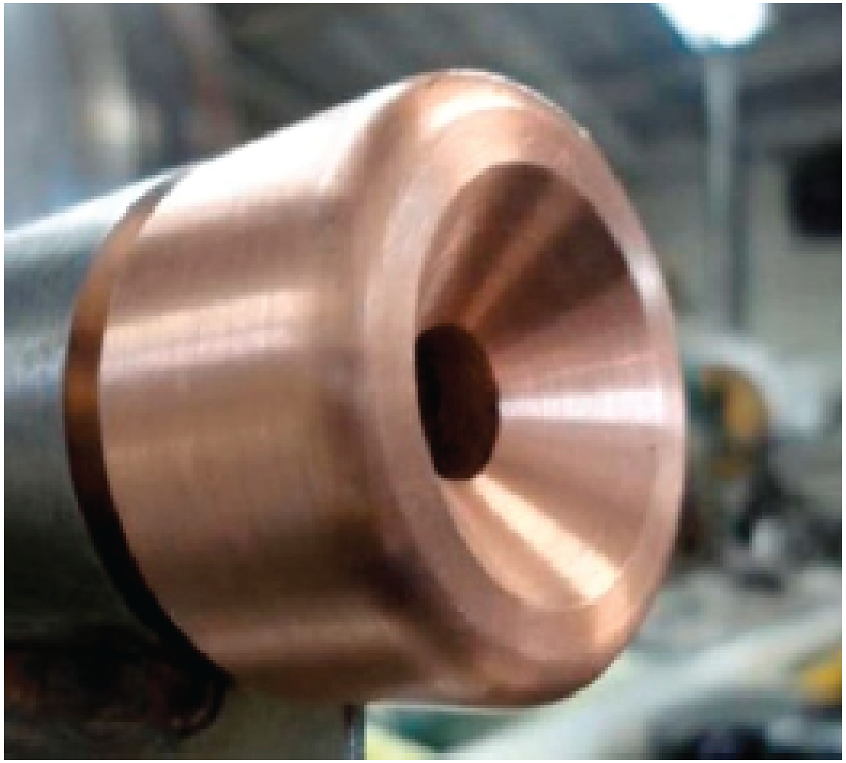
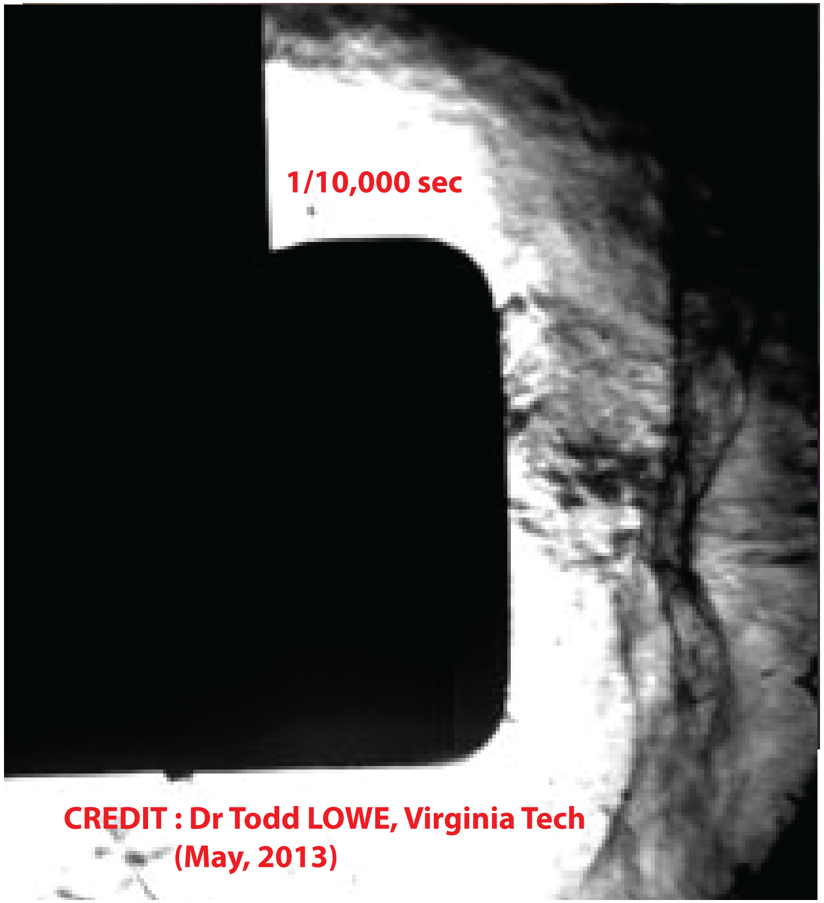
## SLIDE #6: "HYPERSONIC STOCHASTIC SWITCH" USP 9660686 (MARCH 2016)






CREDIT : Dr Todd LOWE, Virginia Tech
(May, 2013)

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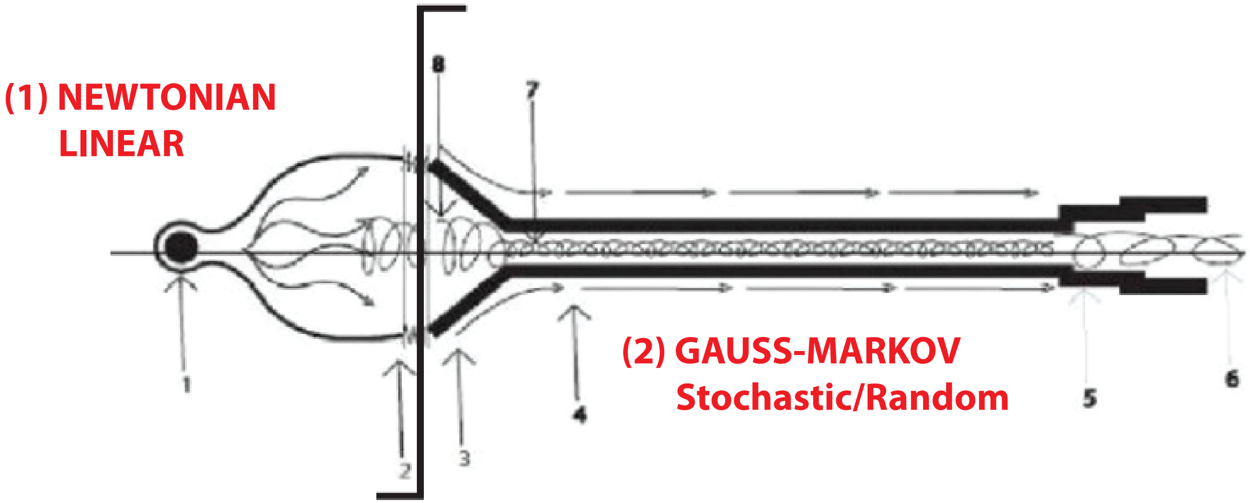
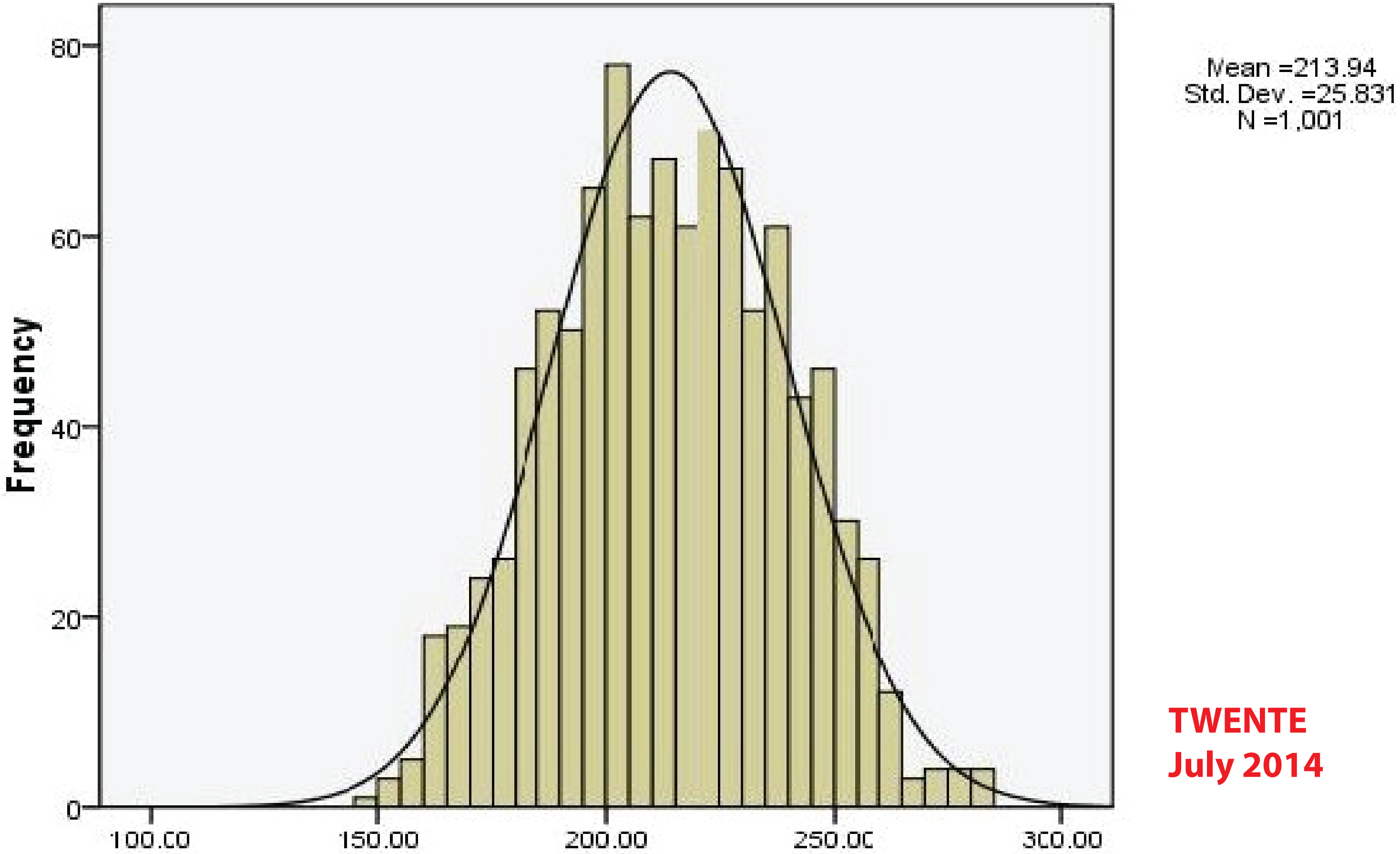
# SLIDE #7: "HYPERSONIC STOCHASTIC SWITCH" USP 9660686 (MARCH 2016)




HYPERSONIC STOCHASTIC SWITCH

1. High pressure cryogenic source
2. Isentropic hypersonic expansion
3. SPINNX hypersonic vortex conversion choke
4. SPINNX regenerative heat flux
5. Joule-Tomson throttling ramp

# SLIDE #8: HYPERSONIC GAUSS-MARKOV RANDOMNESS, TWENTE 2014




**TWENTE**
**July 2014**

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# SLIDE #9: HYPERSONIC STOCHASTIC RANDOMNESS, APS PORTL. JUNE 2019

## "1st MOMENT OF PROBABILITY";

3.1428571429

| Int | Rndm | ln | ^2 | ^3 | ^4 | ^0.286 | 1-^0.286 | ^0.286-1 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.00 | 1 | 0.94 | 1 | 1.00 | 0.000 | 0.00 |
| 2 | 4 | 1.39 | 16 | 0.95 | 256 | 1.49 | -0.120 | 0.49 |
| 3 | 2 | 0.69 | 4 | 0.94 | 16 | 1.22 | -0.058 | 0.22 |
| 4 | 8 | 2.08 | 64 | 0.97 | 4096 | 1.81 | -0.185 | 0.81 |
| 5 | 5 | 1.61 | 25 | 0.95 | 625 | 1.58 | -0.141 | 0.58 |
| 6 | 7 | 1.95 | 49 | 0.96 | 2401 | 1.74 | -0.173 | 0.74 |
| 7 | 1 | 0.00 | 1 | 0.94 | 1 | 1.00 | 0.000 | 0.00 |
| 8 | 4 | 1.39 | 16 | 0.95 | 256 | 1.49 | -0.120 | 0.49 |
| 9 | 2 | 0.69 | 4 | 0.94 | 16 | 1.22 | -0.058 | 0.22 |
| 10 | 9 | 2.20 | 81 | 0.97 | 6561 | 1.87 | -0.197 | 0.87 |
| 10 | 43 | 11.99 | 261 | 9.53 | 3418801 | 2.93 | -0.360 | 4.43 |
| XXXX | 4.3 | 0.28 | 6.07 | 19.04 | 79507 | 0.07 | -0.008 | 0.10 |
| | | ISOTHERMAL COMPRESSION | | | RADIANT TRANSFER | | | |

**EXTREME NUCLEATE HEAT TRANSFER IN THE CRYOGENIC ZONE, CHMT2019 (TWENTE, NL)**

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# SLIDE #10: CRYOGENIC ROSENSHAW RANDOMNESS© [9.8x]

| 3.1428571429 | | | | | | |
|---|---|---|---|---|---|---|
| Random FUNCT | A | B | C | D | CxD | |
| R | ln(RA) | RB^2 | RC^0.75 | RD^0.24 | RTRANS | |
| 1 | 0.000 | 1.000 | 1.000 | 1.000 | 1.000 | |
| 4 | 1.386 | 16.000 | 2.828 | 1.395 | 3.945 | |
| 2 | 0.693 | 4.000 | 1.682 | 1.181 | 1.986 | |
| 8 | 2.079 | 64.000 | 4.757 | 1.647 | 7.835 | |
| 5 | 1.609 | 25.000 | 3.344 | 1.471 | 4.920 | |
| 7 | 1.946 | 49.000 | 4.304 | 1.595 | 6.865 | |
| 1 | 0.000 | 1.000 | 1.000 | 1.000 | 1.000 | |
| 4 | 1.386 | 16.000 | 2.828 | 1.395 | 3.945 | |
| 2 | 0.693 | 4.000 | 1.682 | 1.181 | 1.986 | |
| 9 | 2.197 | 81.000 | 5.196 | 1.694 | 8.804 | |
| 43 | 11.991 | 261.000 | **28.621** | **13.560** | **42.287** | |
| INDEXED/4.3 | 2.789 **/10** | 60.698 | **6.656** | **3.153** | **9.834** | **<< [10x]** |

**0.28 ISOTHERMAL COMPRESSION**

**FORSTER-ZUBER Transformation**

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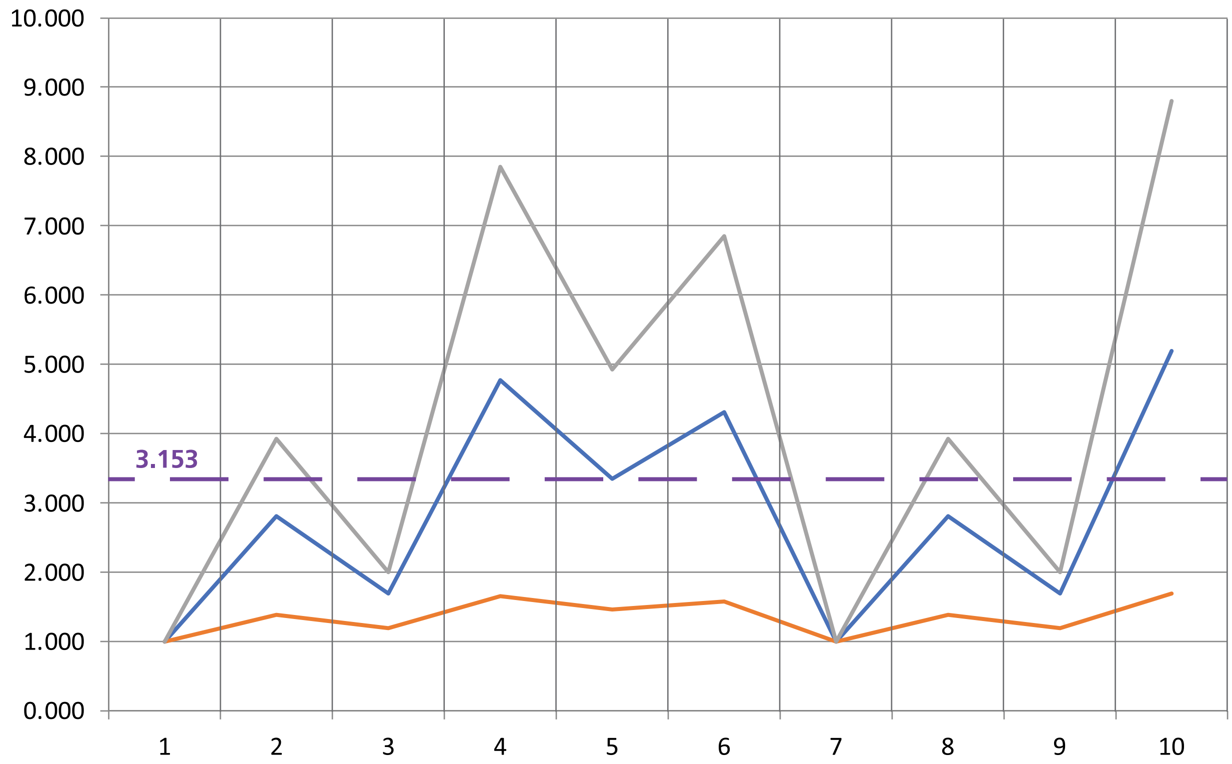
## SLIDE #11: CRYOGENIC ROSENSHAW RANDOMNESS© [PLOT]



**EXTREME NUCLEATE HEAT TRANSFER IN THE CRYOGENIC ZONE, CHMT2019 (TWENTE, NL)**

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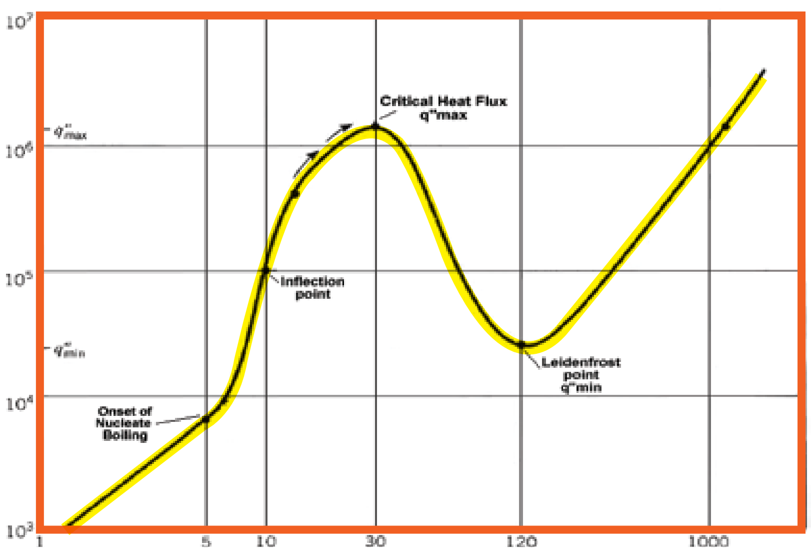
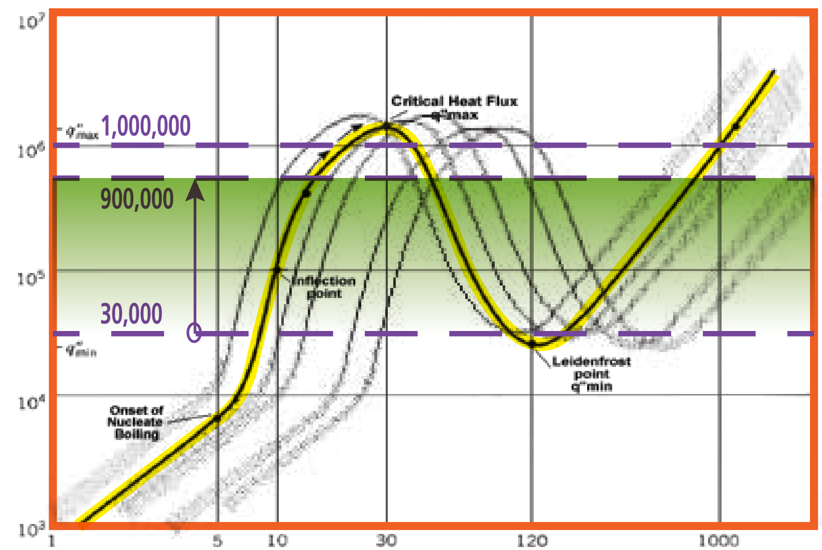
# SLIDE #12: CRYOGENIC ROSENSHAW RANDOMNESS© [SUMMARY]

Because of the nature of the process cryogenic heat and mass transfer generally and condensation/flashing/boiling infers a ((SINGULARITY)). Whereas nature seeks harmonics in its natural habitat (FORESTS/TREES/WIND/SURF/ANIMALS), engineered processes are COST/LIFECYCLE/CAPACITY/OUTPUT optimized without cognizance to natural harmonics. Boiling heat transfer ((ROSENSHAW BOILING CURVE)) is a compelling example of stacking an jamming of bubbles. It is well known that selective lane-change and speed modulation is conducive to freeway efficacy. Randomly (harmonic) staged ((BOILING)) will likewise enhance/expedite/accelerate boiling heat-transfer in accordance with freeway postulation. More pertinently it has been found that ((ISOTHERMAL/HYPERSONIC)) compression a ((SINGULARITY)) defaults into a (perfectly random/harmonic) GAUSS-MARKOV process whereby incipient/adiabatic shockwave formation is transformed into a regenerative ((harmonic)) vortex flux in virtual space. Because boiling heat-transfer can be likewise randomly modulated in the abstract (slide #10), will result in a 10x ((TRANSFER)) multiplier. BECAUSE ((EXTREME/CRYOGENIC)) BOILING/TRANSFORMATION IS EDGING INTO THE LIMELIGHT S/R (STOCHASTIC/RANDOM) MODULATION IS A NECESSARY CRYOGENIC BOILING ATTRIBUTE.




"Stochastic/Random Reset (Stagnation Zone)