TURBULENT STATISTICS OF AN ASYMMTRICALLY HEATED CHANNEL FLOW

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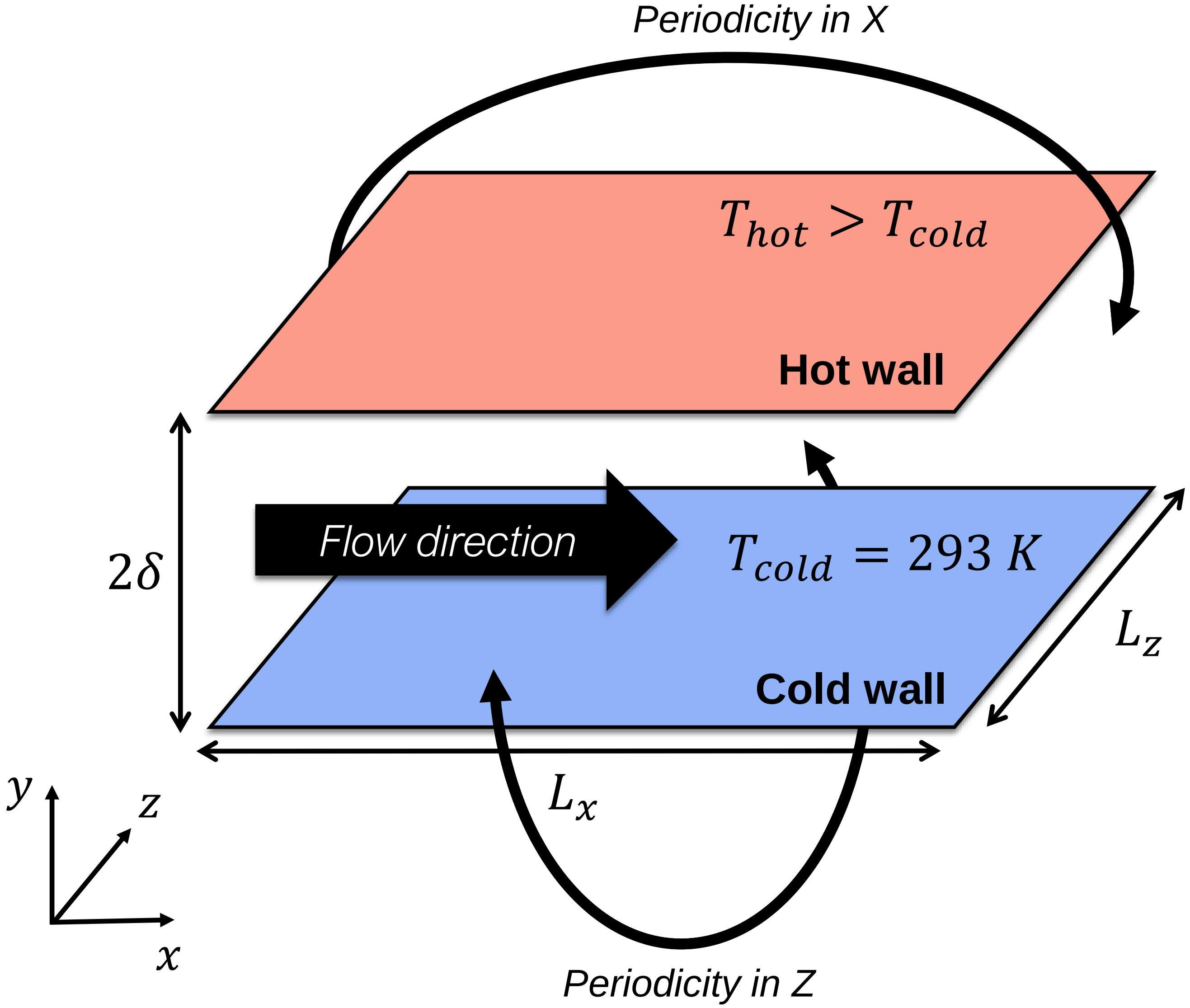
CASE CONFIGURATION



Flow conditions

$M < 0.2$
$Re_{\tau m} = 400$
$Pr = 0.71$
$T_{cold} = 293\ K$
$T_{hot} = 2T_{cold} = 586\ K$
Ideal air properties

Mesh characteristics

Hexahedral elements
Third order elements
76.6 million points
140x140x140

Solver: SOD2D[1]

Low-dissipation
Spectral element method (SEM)
Finite element method (FEM)

[1] Barcelona Supercomputing Center (BSC)

Compressible Navier-Stokes equations:

Continuity: $$\frac{\partial \rho}{\partial t} + \frac{\partial \rho u_i}{\partial x_i} = 0$$

Momentum: $$\frac{\partial \rho u_i}{\partial t} + \frac{\partial \rho u_i u_j}{\partial x_j} = -\frac{\partial p}{\partial x_i} + \frac{\partial \tau_{ij}}{\partial x_j} + f_i$$

$$\tau_{ij} = 2\mu\left(\frac{1}{2}\left(\frac{\partial u_j}{\partial x_i} + \frac{\partial x_i}{\partial x_j}\right) - \frac{1}{3}\frac{\partial u_k}{\partial x_k}\delta_{ij}\right)$$

f_i: Driving force

Energy: $$\frac{\partial \rho E}{\partial t} + \frac{\partial \rho u_j H}{\partial x_j} = \frac{\partial u_i \tau_{ij}}{\partial x_j} + \frac{\partial q_i}{\partial x_i} + \rho f_i$$

$$E = \mathrm{e} + \frac{1}{2} u_i u_i$$

$$q_i = -\lambda \frac{\partial T}{\partial x_i}$$

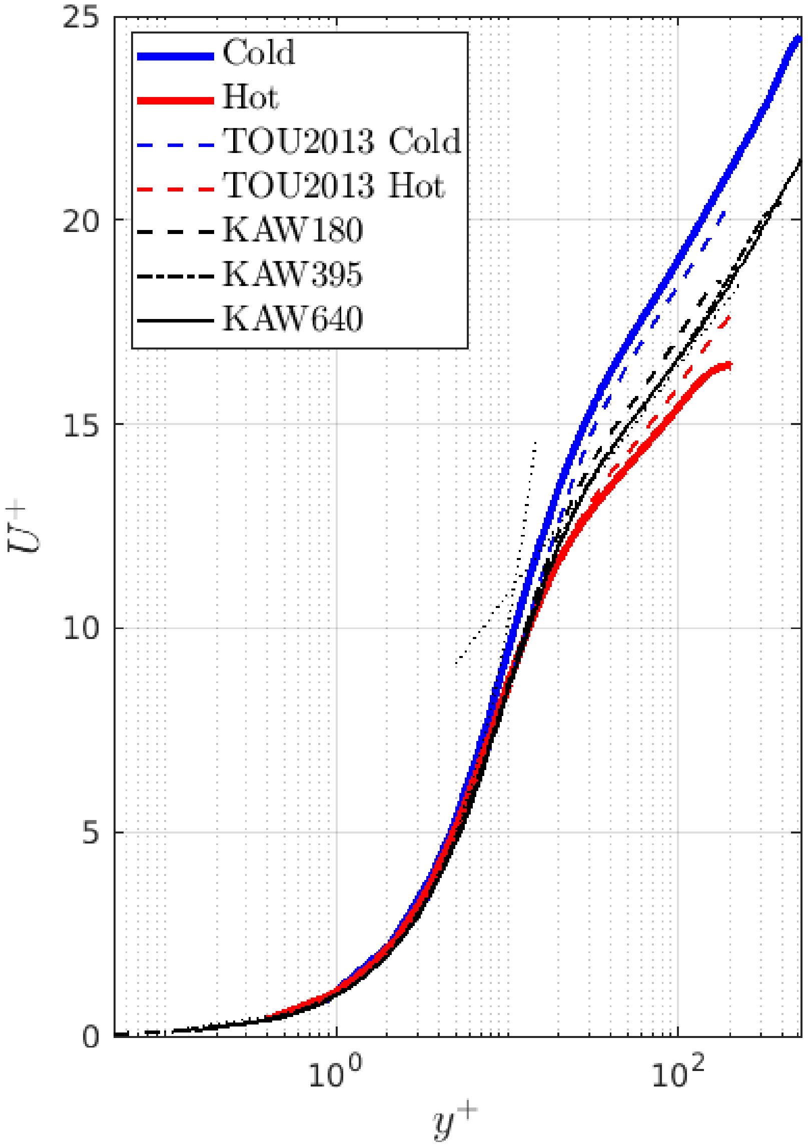
$$H = h + \frac{1}{2} u_i u_i$$

State eq.: $$P_0 = \rho R_g T$$

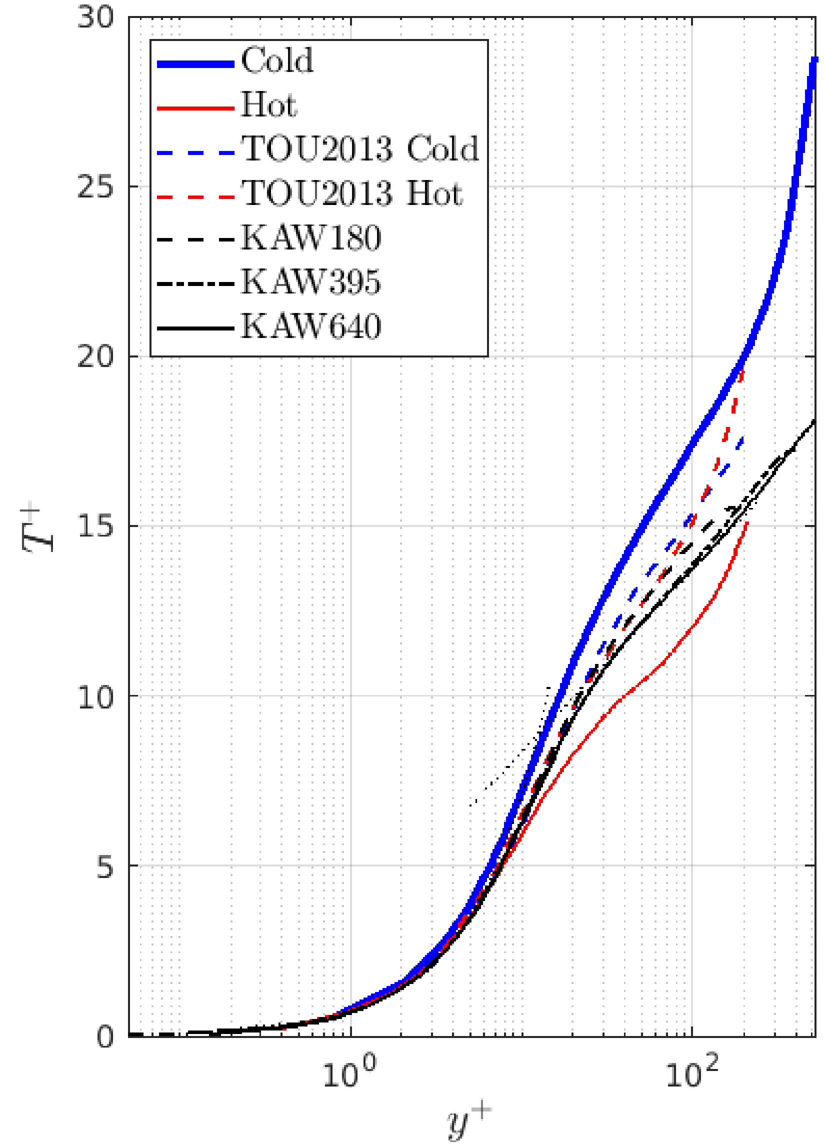
Sutherland's law: $$\mu = \mu_{ref} \frac{T^{3/2}}{T + S}$$

RESULTS

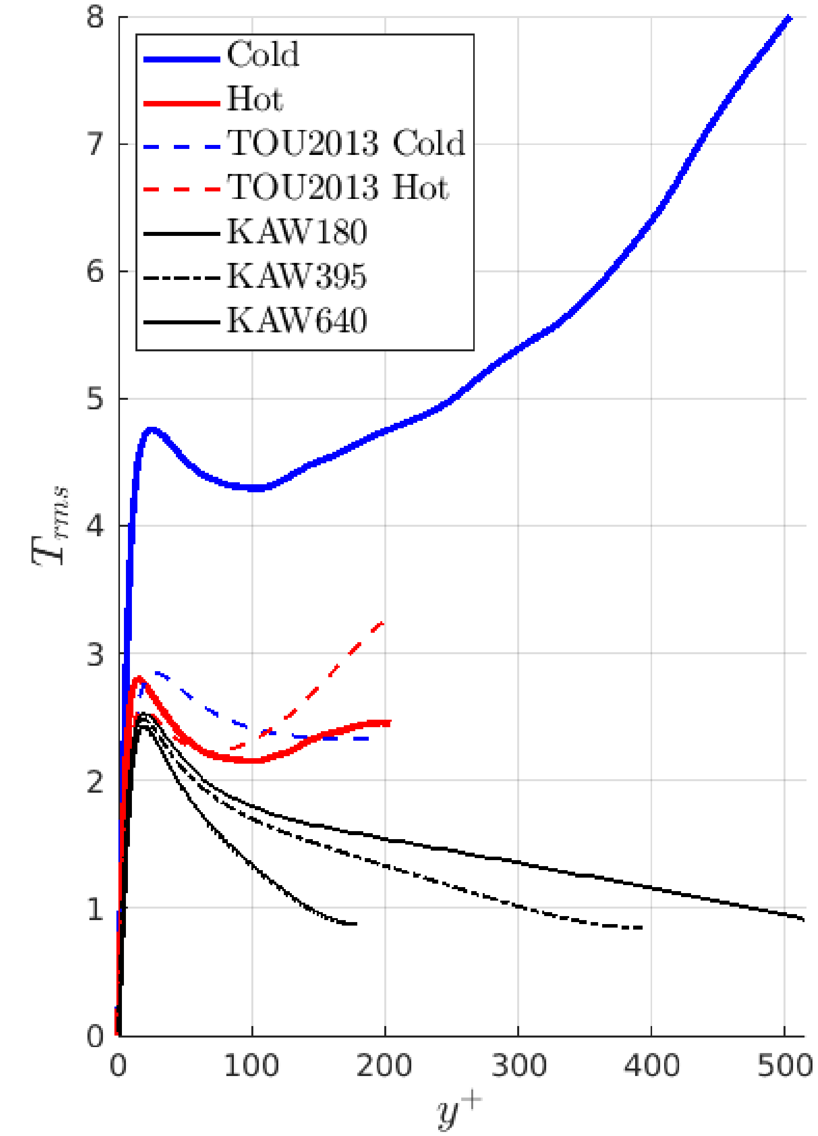
Velocity profile



Temperature profile



Temperature fluctuations



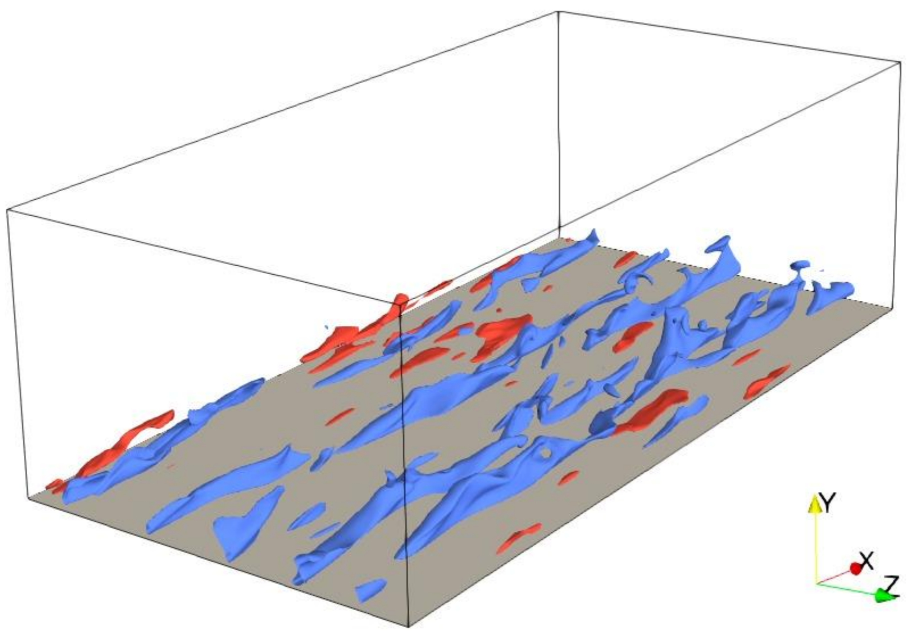
H. Abe, H. Kawamura, and Y. Matsuo, ”Direct Numerical Simulation of a Fully Developed Turbulent Channel Flow With Respect to the Reynolds Number Dependence”, Journal of Fluids Engineering, vol. 123, no. 2, pp. 382–393, Jun. 2001, doi: 10.1115/1.1366680.

H. Abe, H. Kawamura, and Y. Matsuo, ”Surface heat-flux fluctuations in a turbulent channel flow up to Reτ =1020 with Pr=0.025 and 0.71”, International Journal of Heat and Fluid Flow, vol. 25, no. 3, pp. 404–419, Jun. 2004, doi: 10.1016/j.ijheatfluidflow.2004.02.010.

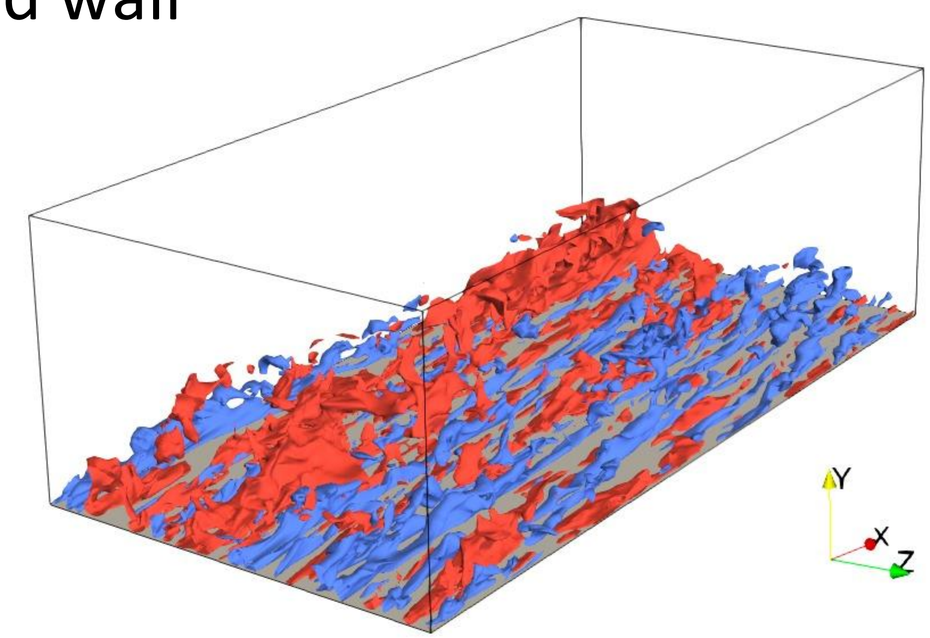
A. Toutant and F. Bataille, “Turbulence statistics in a fully developed channel flow submitted to a high-temperature gradient”, International Journal of Thermal Sciences, vol. 74, pp. 104–118, 2013, doi: 10.1016/j.ijthermalsci.2013.06.003

RESULTS

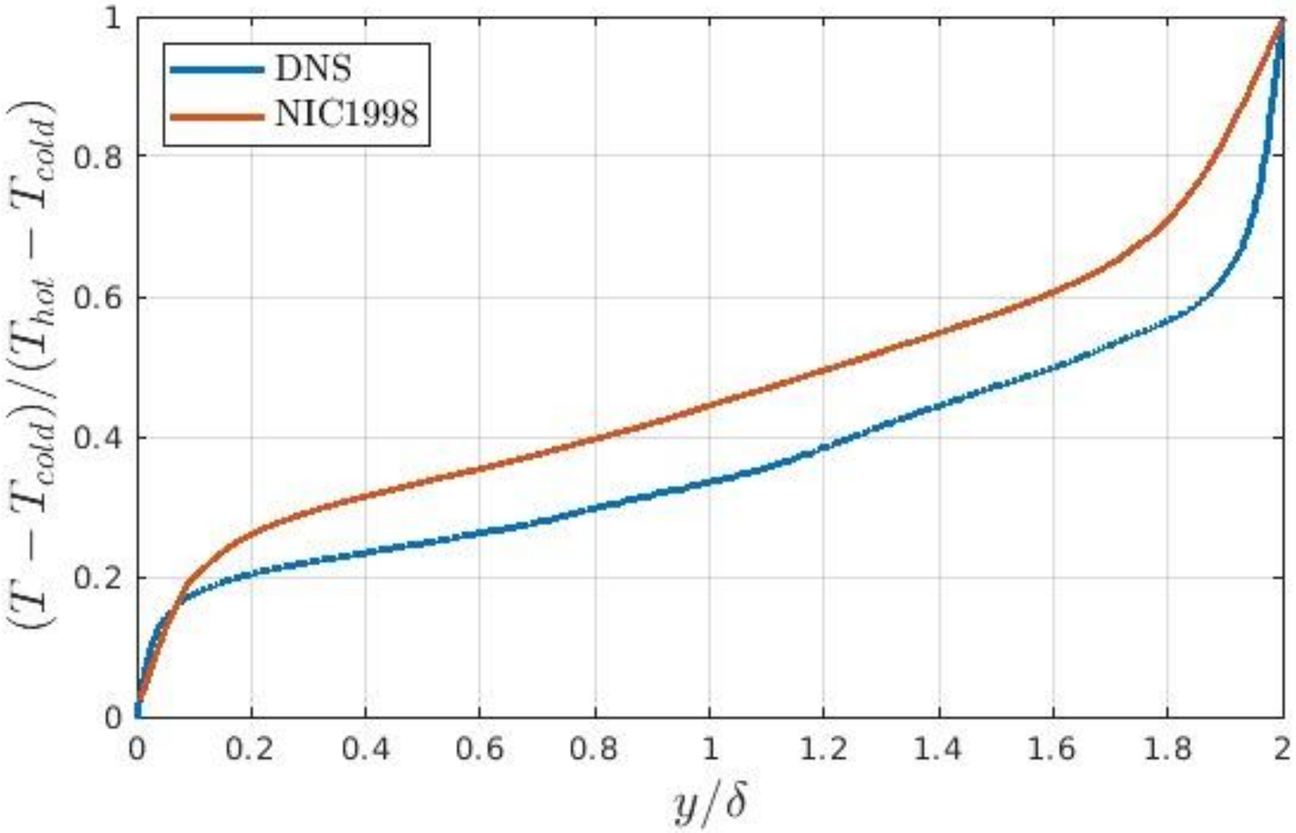
Hot wall



Cold wall



Temperature ratio

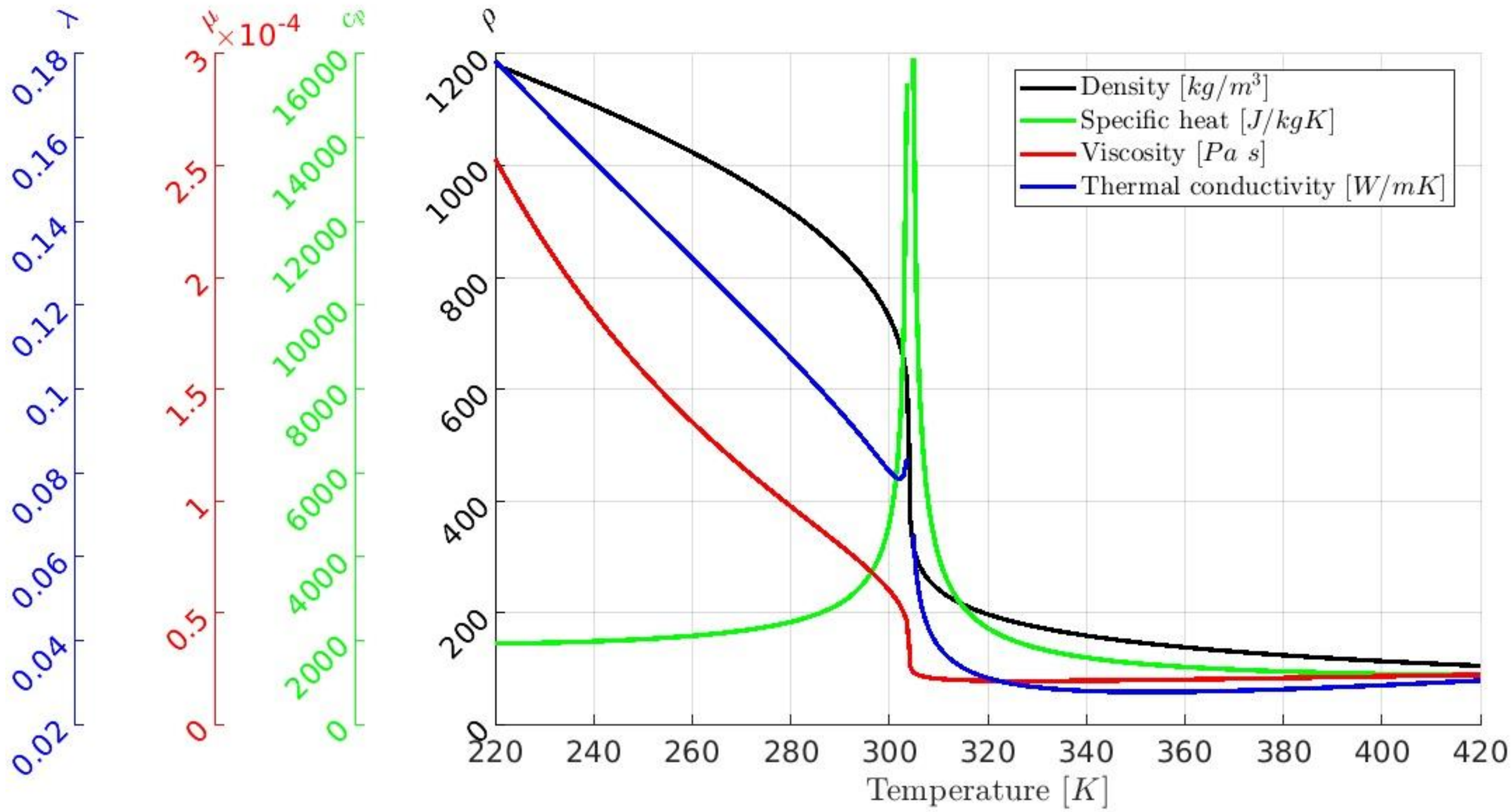


Nicoud, Frank. «Numerical Study of a Channel FLow with Variable Properties». Center for Turbulence Research Annual Research Briefs, 1998, 289-310.

The final results would be presented at the **ETMM14** and the **SFMC23** congresses.

NEXT STEPS

CO2 thermophysical properties at supercritical pressure

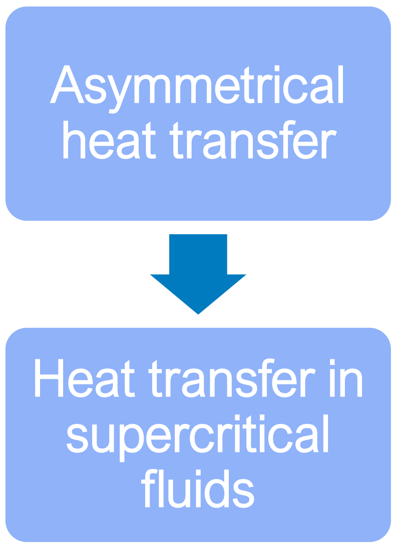


Eric W. Lemmon, Ian H. Bell, Marcia L. Huber, and Mark O. McLinden, "Thermophysical Properties of Fluid Systems" en NIST Chemistry WebBook, NIST Standard Reference Database Number 69, Eds. P.J. Linstrom and W.G. Mallard, National Institute of Standards and Technology, Gaithersburg MD, 20899, https://doi.org/10.18434/T4D303

The final results would be presented at the **ETMM14** and the **SFMC23** congresses.

SFMC23: M. Garcia-Berenguer, L. Gasparino, O. Lehmkuhl and I. Rodriguez, “Turbulent statistics and coherent structures in an asymmetrically heated channel flow”, June 2023 in Spanish Fluid Mechanics Conference, Barcelona, Spain

ETMM14: M. Garcia-Berenguer, L. Gasparino, O. Lehmkuhl and I. Rodriguez, “Large-scale coherent structures in an asymmetrally heated channel flow”, September 2023 in Ercoftac Symposium on Engineering Turbulence Modelling and Measurements, Barcelona, Spain



THANK YOU FOR YOUR ATTENTION

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