



# A new code for the numerical simulation of relativistic flows on supercomputers by means of a low-dissipation scheme

**Dr. of Sc. Igor Kulikov**

**Institute of Computational Mathematics  
and Mathematical Geophysics SB RAS**

**Novosibirsk, Russia**

**[kulikov@ssd.sccc.ru](mailto:kulikov@ssd.sccc.ru)**



# RHydroBox3D code

Domain Decomposition



Geometry Decomposition

MPI



Threads Decomposition  
OpenMP / POSIX Threads

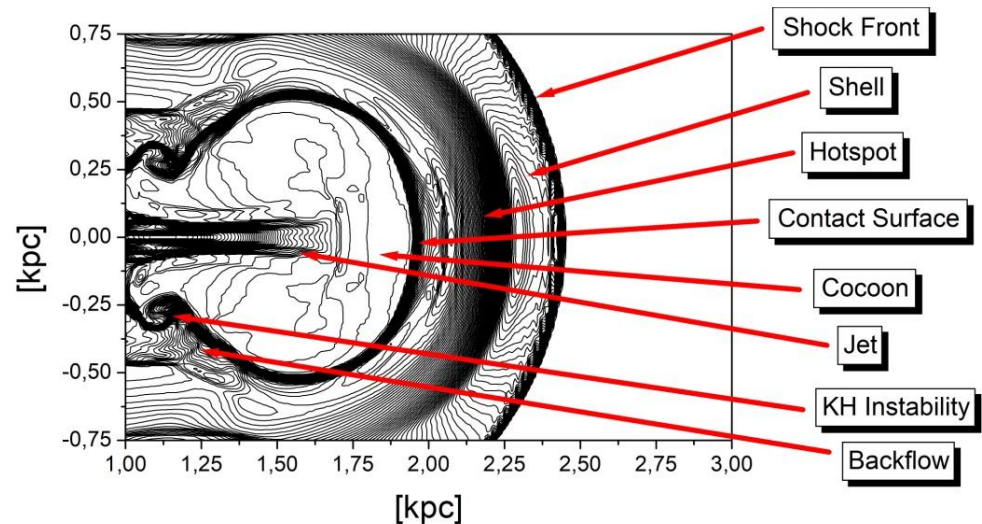


Vectorization  
AVX 512

$$F = \frac{1}{2} \times (f_L + f_R) + \frac{c + \|\vec{u}\|}{2} \times (v_L - v_R)$$

Diagram illustrating the Riemann flux calculation formula with annotations for AVX-512 instructions:

- $\frac{1}{2}$ : `_mm512_stream_pd`
- $f_L + f_R$ : `_mm512_add_pd`
- $\times$  (multiplication): `_mm512_mul_pd`
- $c + \|\vec{u}\|$ : `_mm512_add_pd`
- $\frac{1}{2}$  (second): `_mm512_stream_pd`
- $\times$  (multiplication): `_mm512_mul_pd`
- $v_L - v_R$ : `_mm512_sub_pd`



# CV

**Igor Kulikov** Doctor of Science, Professor  
[kulikov@ssd.sccc.ru](mailto:kulikov@ssd.sccc.ru)

Specialist in solving hydrodynamics equation,  
computational astrophysics parallel computing,  
and HPC software development.



**Kulikov I.** A new code for the numerical simulation of relativistic flows on supercomputers by means of a low-dissipation scheme // **Computer Physics Communications.** – 2020. – V. 257. – Article Number 107532.

**Kulikov I., Chernykh I., Tutukov A.** A new hydrodynamic code with explicit vectorization instructions optimizations, dedicated to the numerical simulation of astrophysical gas flow. I. Numerical method, tests and model problems // **The Astrophysical Journal Supplement Series.** – 2019. – V. 243. - Article Number 4.

**Kulikov I., Vorobyov E.** Using the PPML approach for constructing a low-dissipation, operator-splitting scheme for numerical simulations of hydrodynamic flows // **Journal of Computational Physics.** – 2016. – V. 317. – P. 318-346.