



St Petersburg
University
www.spbu.ru

ALGORITHMS FOR THE CALCULATION OF NONLINEAR PROCESSES ON HYBRID ARCHITECTURE CLUSTERS

Alexander Bogdanov

Vladimir Mareev

Nikita Storublevtcev

Introduction

- Some problems are too intensive for superscalar systems.
- There aren't many true vector-based systems.
- GPU's being in essence vector accelerators provide some hope for breaking the stalemate.

Initial Problem

For the test problem we use

Two-dimensional Kadomtsev-Petviashvili equation — KPI

$$[u_t + 0.5(u^2)_x + \beta u_{xxx} - G]_x = \eta u_{yy} \quad (1)$$

$u(x, y, t)$ is considered in the domain

$$t \geq 0,$$

$$x, y \in (-\infty, \infty), \beta, \eta \geq 0,$$

$G(x, y)$ is external source.

Governing Equations

Integro-differential analogue KPI

$$u_t + 0.5(u^2)_x + \beta u_{xxx} = \eta \int_{-\infty}^x u_{yy}(x', y, t) dx' + G(x, y) \quad (2)$$

Initial distribution: $u(x, y, 0) = q(x, y)$

The numerical simulation of the equation (2) is carried out using **a linearized implicit finite-difference scheme** using in some cases the flux correction procedure (**FCT**).

For equation (2), the approximation is performed using the central-difference operators.

The Boundary Conditions

$u_x = u_{xx} = 0$ along boundary lines x_1 and x_M ,
and $u_y = 0$ along the lines y_1 and y_L .

In difference form the differential conditions look like:

$$u_{-1,k}^n = u_{0,k}^n = u_{1,k}^n;$$

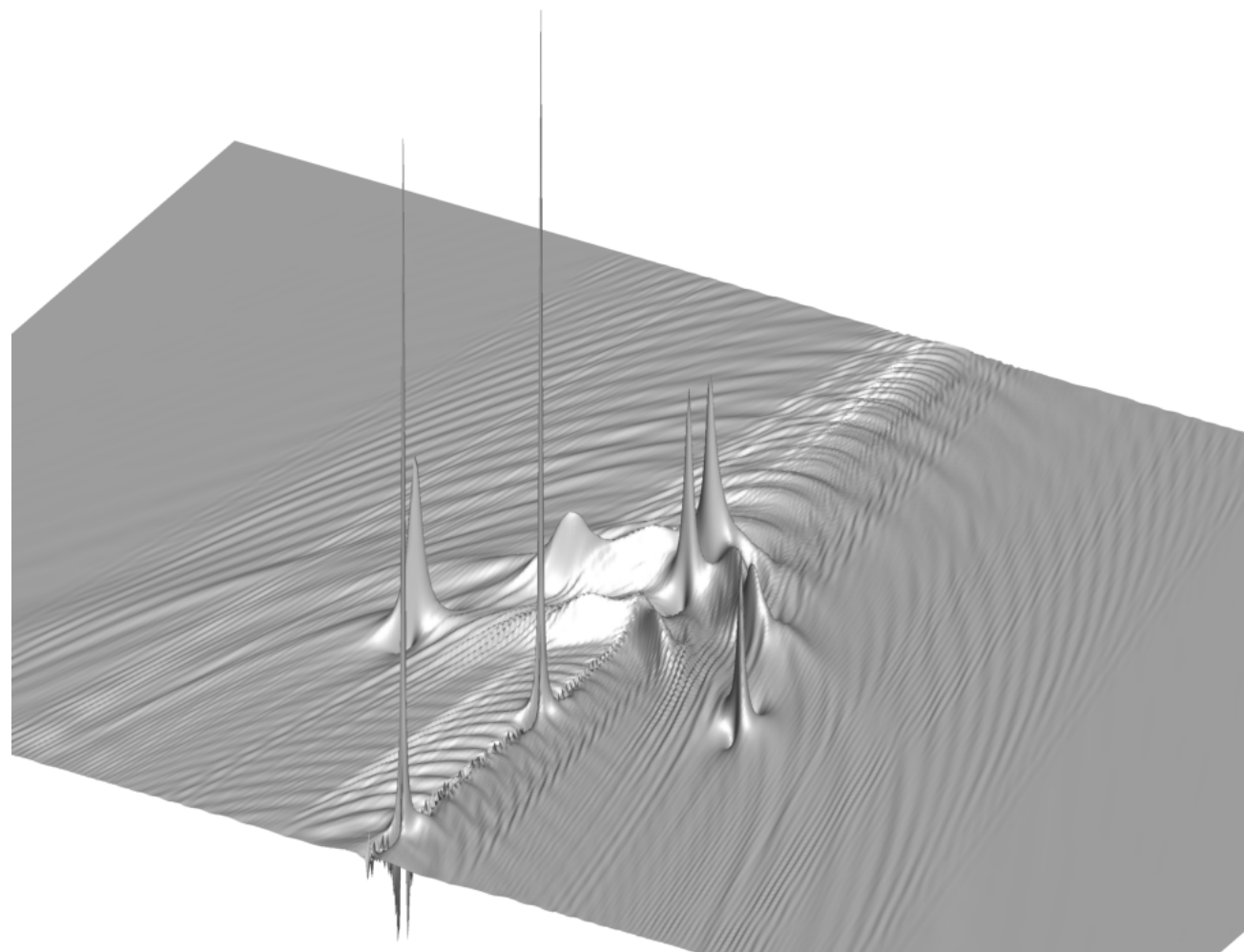
$$u_{M+2,k}^n = u_{M+1,k}^n = u_{M,k}^n;$$

$$u_{j,0}^n = u_{j,1}^n; \quad u_{j,L+1}^n = u_{j,L}^n$$

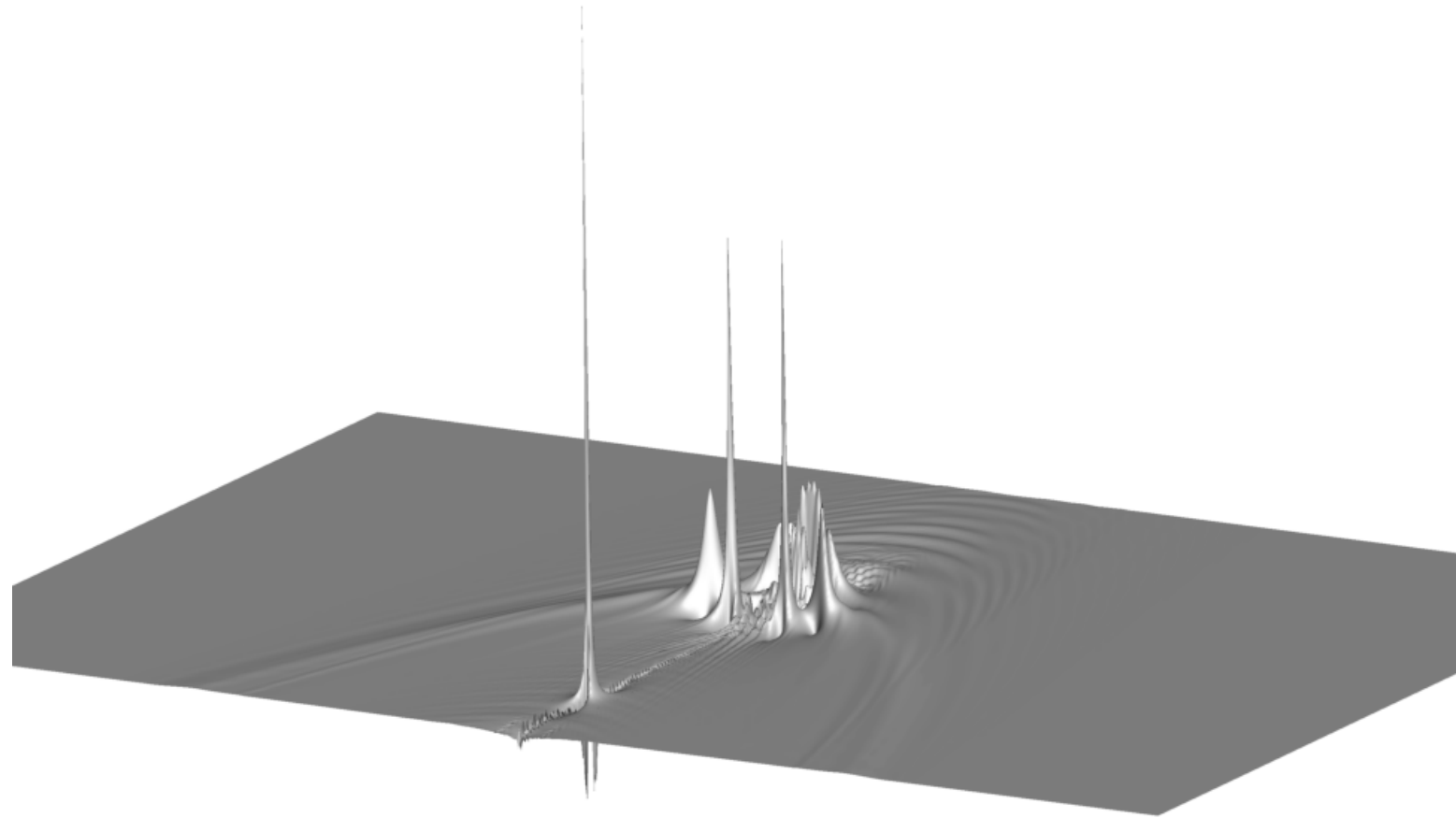
Influence of the Source

We chose a source in the form of an ellipsoid of rotation, as in the case of 3 for initial distributions:

$$G(x, y) = c_4 \sqrt{1 - \frac{(x - x_0)^2}{a_4^2} - \frac{(y - y_0)^2}{b_4^2}}$$



Source-only 3D perturbation at $t = 15.5$.
Grid: 600×850 , $\Delta t = 10^{-4}$, $\Delta x = \Delta y = 0.2$.



Source-only 3D perturbation at $t = 7$, $V = 30\pi$, $a_4 = 2$, $b_4 = 3$, $c = 7.5$.

Grid: 600×850 , $\Delta t = 10^{-4}$, $\Delta x = \Delta y = 0.2$.

Conclusion

- We ported of the predictor-corrector algorithm of solving non-linear problems on hybrid architecture. Using KPI as an example.
- It allowed us to create software and hardware platform for mass computations of wave processes.



Thank you.
Questions?

St Petersburg University
spbu.ru