

Marchuk Scientific Readings
Second Workshop
on Numerical Modeling in MHD
and Plasma Physics:
Methods, Tools, and Outcomes

October 10-11, 2019
Moscow, Russia

Организаторы конференции

**Институт вычислительной математики
и математической геофизики СО РАН**

**Институт прикладной математики
им. М.В. Келдыша РАН**

при поддержке

Commission B1 Computational astrophysics IAU

Сайт конференции <http://conf.nsc.ru/mhd19/en>

E-mail mhd2019@sscc.ru

Направления работы конференции

- **Методы решения МГД уравнений**
- **Методы частиц-в-ячейках**
- **Высокопроизводительные вычисления**
- **Вычислительная гидродинамика**
- **Вычислительная физика плазмы**
- **Вычислительная астрофизика**

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Galina Dudnikova co-chair

ICM&MG SB RAS, Novosibirsk, Russia

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Eugene Stepin **chair**

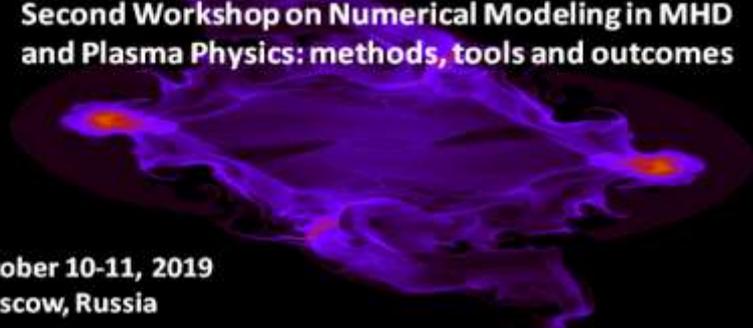
Keldysh Institute of Applied Mathematics of RAS, Moscow, Russia

Aleksei Taiurskii

Keldysh Institute of Applied Mathematics of RAS, Moscow, Russia

Объявление о конференции

Marchuk Scientific Readings
Second Workshop on Numerical Modeling in MHD and Plasma Physics: methods, tools and outcomes



October 10-11, 2019
Moscow, Russia

Program Committee
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Mikhail Marchenko
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Boris Rybakin
Alexander Tutukov
Eduard Vorobyov
Vitaly Vshivkov
Victor Zhukov

Topics
Numerical methods for MHD equations
Particle-in-cell method
High performance computing
Computational Fluid Dynamics
Computational Physics of Plasma
Computational Astrophysics

Proceedings
Journal of Physics: Conference Series

Important dates
Abstracts deadline **June, 25**
Notification of acceptance **July, 10**
Papers deadline **August, 1**
Registration fee deadline **September, 1**

Web site <http://conf.nsc.ru/mhd19/en>

Email mhd2019@sscc.ru

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The workshop was supported by Commission B1 Computational astrophysics IAU

Second Workshop on Numerical Modeling in MHD and Plasma Physics: Methods, Tools, and Outcomes
October 10-11, 2019, Moscow, Russia

General information

Institute of Computational Mathematics and Mathematical Geophysics
of Siberian Branch of Russian Academy of Sciences
**Keldysh Institute of Applied Mathematics
of Russian Academy of Sciences**
supported by
Commission B1 Computational astrophysics IAU
holds
**Marchuk Scientific Readings
Second Workshop on Numerical Modeling in MHD and Plasma Physics:
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**October 10-11, 2019
Moscow, Russia**

Conference web-site <http://conf.nsc.ru/mhd19/en> **E-mail** mhd2019@sscc.ru

Canadian Astronomy Data Centre



International Astronomy Meetings

Second Workshop on Numerical Modeling in MHD and Plasma Physics: Methods, Tools, and Outcomes

Date	Thursday, 10 October 2019 - Friday, 11 October 2019
Location	Moscow, Russia
Contact	Igor Khabib
Address	Keldysh Institute of Applied Mathematics, Zhukovskiy st. 4 Moscow, 125080, Russia
Phone	
URL	http://conf.nsc.ru/mhd19/en
Email	mhd2019@sscc.ru
Proceedings	
Keywords	Numerical methods for MHD equations, Particle-in-cell method, High performance computing, Computational Fluid Dynamics, Computational Physics of Plasma, Computational Astrophysics
Website	SSCC

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Секции конференции

- Математическое моделирование в физике плазмы
3 секции
- Математическое моделирование в астрофизике
2 секции
- Численные методы решения гидродинамических уравнений и уравнения Пуассона
- Высокопроизводительные вычисления в астрофизике и физике плазмы
- Гидродинамическое моделирование в физике Земли

Статистика конференции

Организации	Число участников
• ИПМ РАН	15
• ИВМиМГ СО РАН	11
• ИКИ РАН	5
• ИММ УрО РАН	2
• Институт астрономии РАН	1
• РФЯЦ-ВНИИЭФ (Саров)	2
• ОИЯИ (Дубна)	1
• МГУ	1
• НГУ	1
• РУДН	1
• ARIES (Найнитал, Индия)	1 (skype)
• Flatiron Institute (Нью-Йорк, США)	1 (skype)

Модель равновесной плазмы (Брушлинский К.В.)

Plasmastatics

MHD equilibrium

$$\nabla p = [\mathbf{j}, \mathbf{H}]$$

$$\mathbf{j} = \text{rot } \mathbf{H}$$

$$\text{div } \mathbf{H} = 0 \quad (\rightarrow \mathbf{H} = \text{rot } \Psi)$$

Analogue: stationary dynamic of incompressible liquid

$$\nabla \left(C - p - \frac{\mathbf{v}^2}{2} \right) = [\mathbf{\Omega}, \mathbf{v}] \quad \leftarrow ((\mathbf{v}, \nabla) \mathbf{v} + \nabla p = 0)$$

$$\mathbf{\Omega} = \text{rot } \mathbf{v}$$

$$\text{div } \mathbf{v} = 0$$

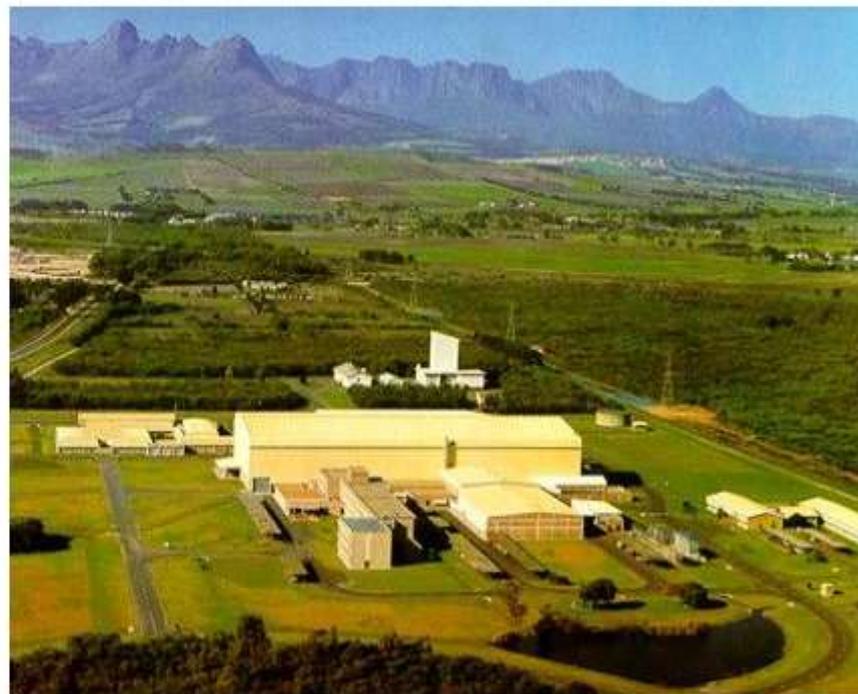
(Shafranov, 1957)

Моделирование ионного пучка (Бойцов А.)

Motivation



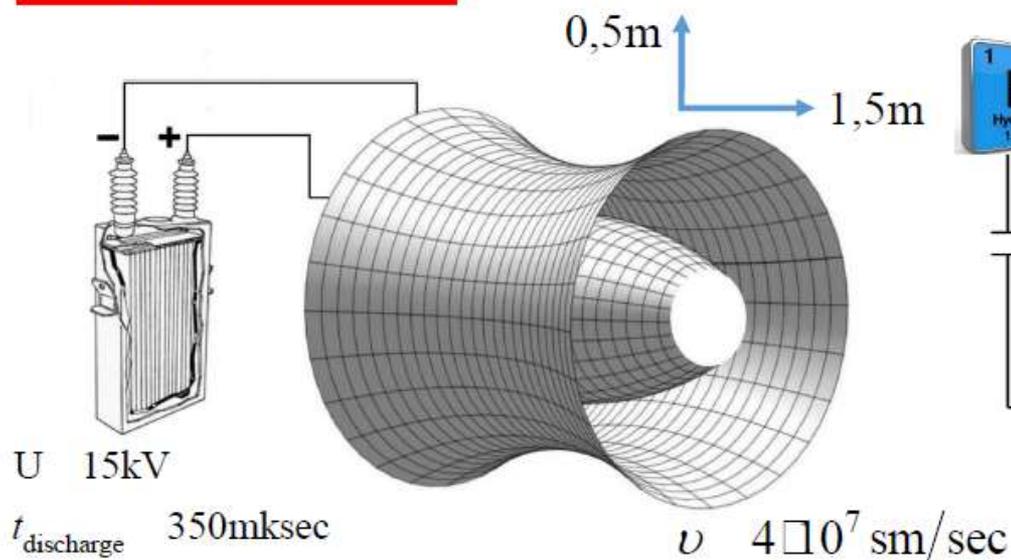
Dubna, NICA facility
Requirements for ion source:
 Au^{32+} 10^9 particles per pulse
Repetition rate 50 Hz (3 pulses to Booster, less 20ms)



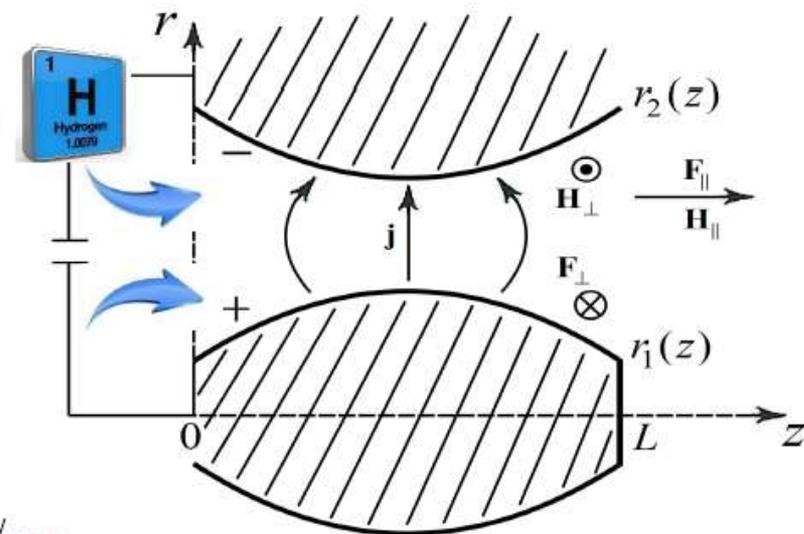
South Africa, Ithemba labs.
Charge breeding rare isotopes

Суб-Альфвеновские течения (Степин Е.)

Object of modeling



Schematic view of coaxial plasma accelerator

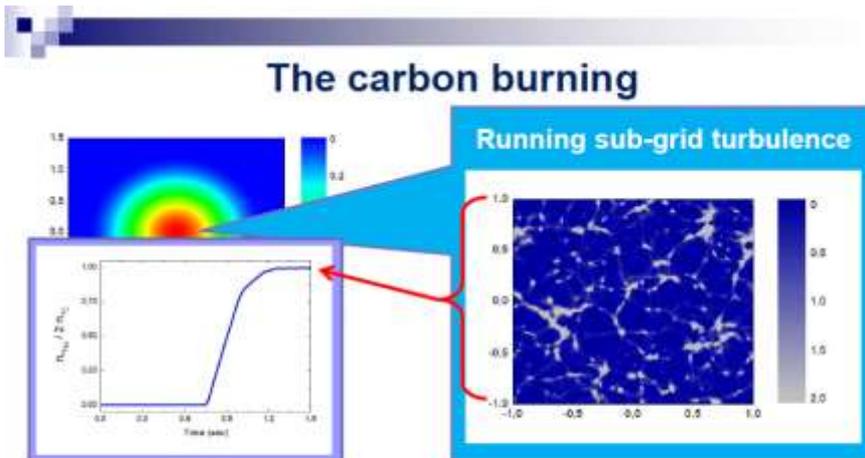
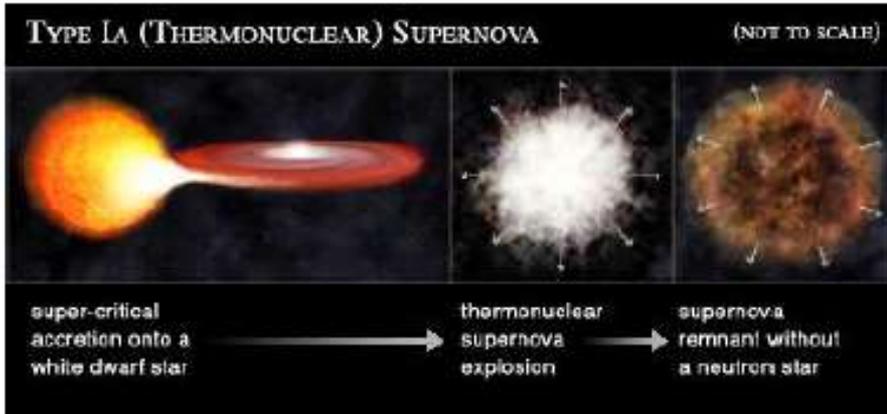


Cross-section by plane $\varphi = \text{const}$

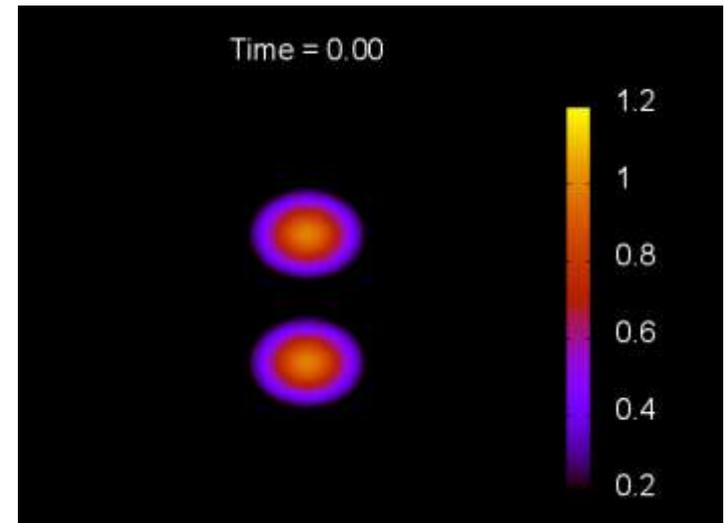
$$\mathbf{F}_{\parallel} = (1/c) \mathbf{j} \times \mathbf{H}_{\perp} - \text{causes plasma acceleration}$$

$$\mathbf{F}_{\perp} = (1/c) \mathbf{j} \times \mathbf{H}_{\parallel} - \text{causes plasma rotation}$$

Нестандартность сверхновой Ia (Тутуков А.В., Куликов И.М.)



The final concentrations of ^{12}C ... ^{56}Ni return to the hydrodynamic simulation



Образование гидрида гелия в галактиках-медузах (Куликов И.М., Черных И.Г., Тутуков А.В.)

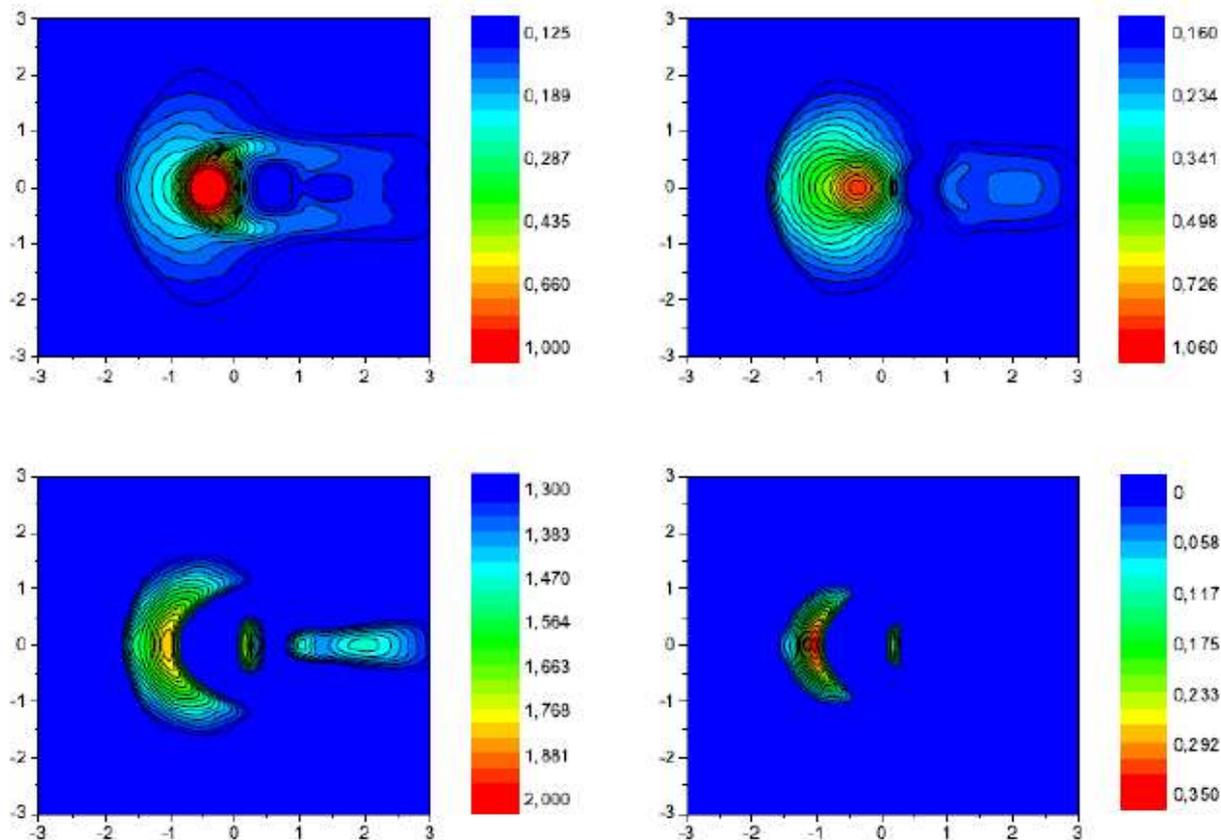


Figure 1. The density in cm^{-3} (top left), the relative pressure (top right), the temperature in T_A (bottom left) and density in 10^{-6}cm^{-3} of the helium hydride ion (bottom right).

Энергия аккреции в черных дырах (Sarkar S.)

Introduction :

- **Accretion** : Accumulation of matter onto a compact object (white dwarfs, neutron stars and black holes) due to its gravitational potential energy. Principal source of power in AGN's, in close binary systems etc.

- Energy released due to accretion : $\Delta E = \frac{GM_*m}{R_*} = \frac{GM_*m}{\chi r_s}$

$$\rightarrow \Delta E = \frac{mc^2}{2\chi}$$

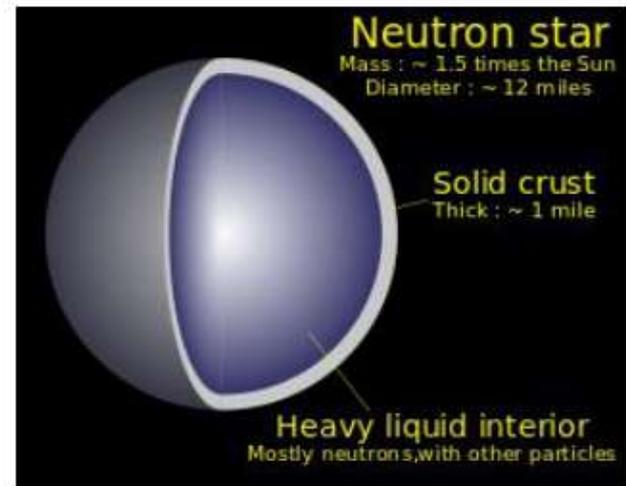
- Accretion flow around BHs consist of ionised plasma : protons and electrons
- Electrons have lower inertia than protons. They are the ones which radiate : Accretion flow is **bound to have two different temperatures**
- In most of the astrophysical cases : $t_{infall} < t_{ion-electron\ collision}$
Protons and electrons become **weakly coupled**.
=> Coulomb coupling (Γ_{ep}) between electrons and protons are **not strong**.



Need correct two temp solutions, because that generates correct spectra !

Neutron stars: Briefly

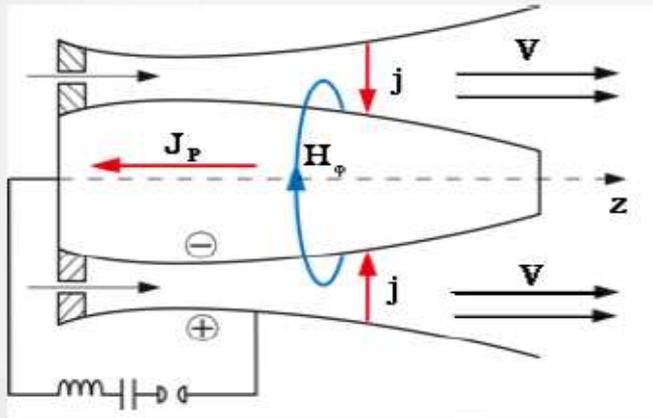
- A compact relativistic star
- The final stage of a stellar evolution of massive stars ($M \gtrsim 8M_{solar}$)
- Products of core-collapse supernovae ($E_{expl} \sim 10^{51} \text{ ergs}$)
- Very compact objects ($R \sim 10 \text{ km}$)
- Huge densities ($\rho_c \sim 10^{14-15} \text{ g/cm}^3$)
- Huge magnetic fields ($B_s \sim 10^{12-14} \text{ G}$)
- Effective temperatures $T_s \sim 10^6 \text{ K}$ (*isolated NSs*)



Перенос излучения в ионизированном газе (Козлов А.Н.)

Quasi-steady plasma accelerators (QSPA)

Scheme of a plasma accelerator



$\mathbf{H} = (0, H_\varphi, 0)$ – magnetic field

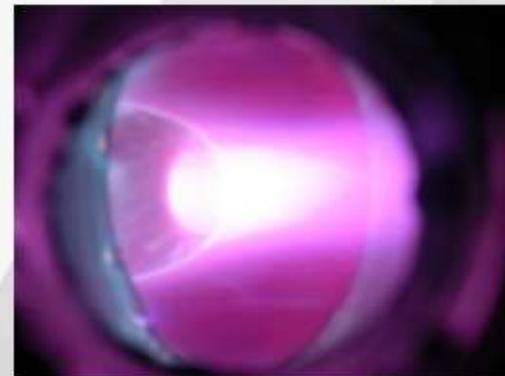
$\mathbf{F}_{\text{Amp}} = \frac{1}{c} [\mathbf{j}, \mathbf{H}]$ – Ampere force

\mathbf{j} - current in plasma

Simple plasma accelerator



Plasma flux in the experiment



Турбулентное вихревое динамо (Левина Г.В.)

HURRICANES: MONITORING AND PREPAREDNESS

National Hurricane Center (NHC) <https://www.nhc.noaa.gov/>

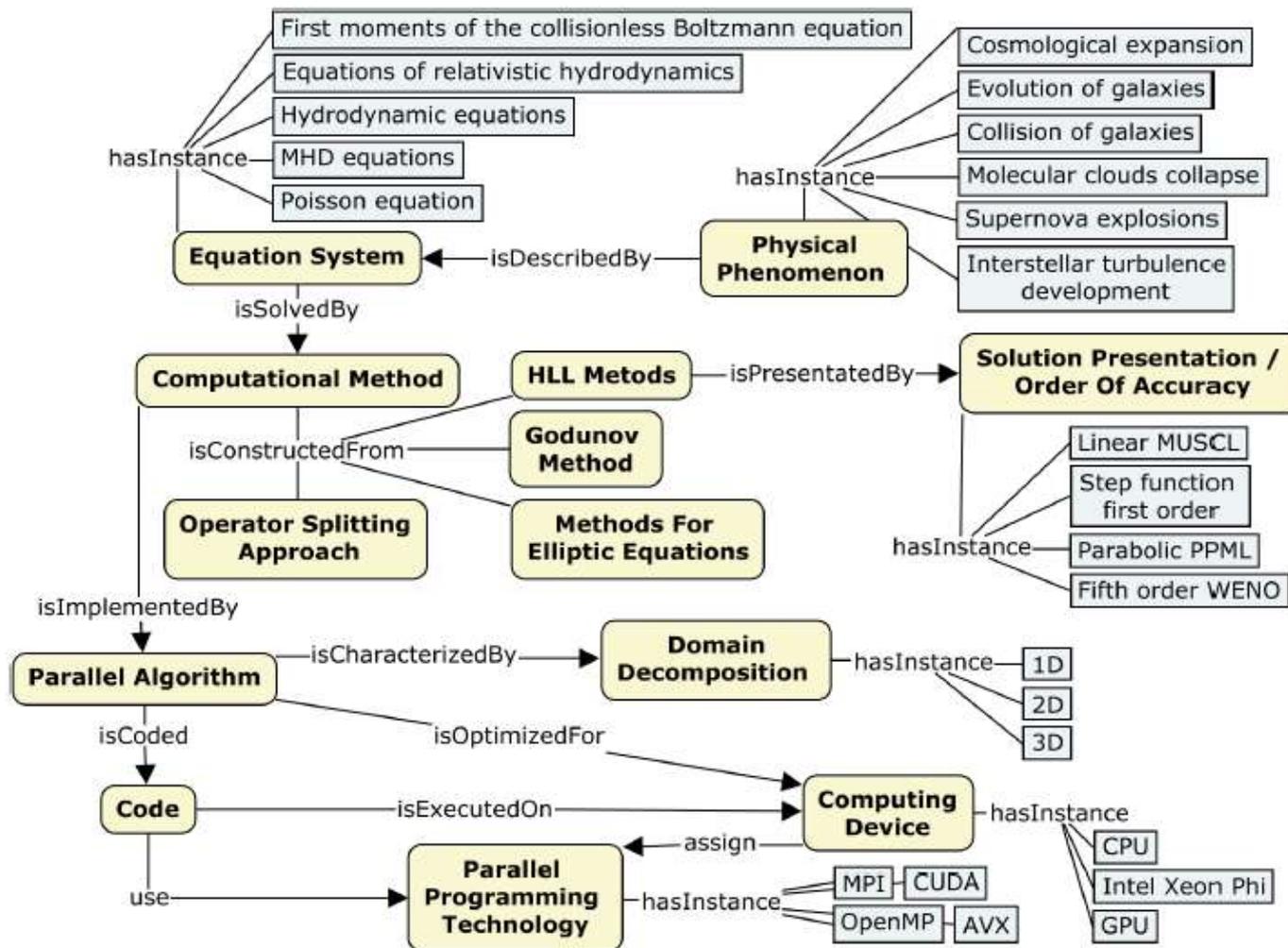


-  TD – tropical depression, $V \leq 17$ m/s – **ALARM** – the tropical cyclone (TC) is formed
-  TS – tropical storm, $V = 18-32$ m/s

There are enough cases when, despite all efforts, TD stage is missed and TC is identified at its next stage of tropical storm – TS, and very close to heavily populated areas, e.g. TS Karl (2010) near Honduras

Генерация кодов на основе онтологий (Сапетина А.Ф.)

Intelligent support ontology for solving compute-intensive astrophysics problems



Чебышевские решатели (Жуков В.Т.)

Adaptation of Chebyshev iterative method

$$\mathbf{A}\mathbf{u} = \mathbf{f}, \quad \mathbf{A} = \mathbf{A}^* > \mathbf{0}, \quad \text{Sp}(\mathbf{A}) \subset [\lambda_{\min}; \lambda_{\max}]$$

$$\mathbf{u}_{k+1} = \mathbf{u}_k - \tau_{k+1}(\mathbf{A}\mathbf{u}_k - \mathbf{f}), \quad k = 0, 1, \dots, p-1,$$

\mathbf{u}_0 is initial guess,

$$\mathbf{r}_p = \mathbf{f} - \mathbf{A}\mathbf{u}_p, \quad \mathbf{r}_p = \mathbf{F}_p(\mathbf{A}) \mathbf{r}_0, \quad \mathbf{F}_p(\mathbf{A}) = \prod_{k=1}^{p-1} (\mathbf{I} - \tau_k \mathbf{A})$$

$$\{\tau_k\} = \arg \min_{\mathbf{F}} [\max_{\lambda_{\min} \leq \lambda \leq \lambda_{\max}} |\mathbf{F}_p(\lambda)|], \quad \mathbf{F}_p(\mathbf{0}) = \mathbf{1}$$

$$\tau_k^{-1} = 0.5 (\lambda_{\max} + \lambda_{\min}) - 0.5 (\lambda_{\max} - \lambda_{\min}) \cdot \beta_k$$

$$\beta_k \in \mathbf{K}_p = [\cos((i-0.5)\pi/p), i = 1, 2, \dots, p] -$$

set of roots of Chebyshev polynomial T_p .

Труды конференции

**Journal of Physics:
Conference Series
Volume 1336
2019
(WoS/SCOPUS)**



The editorial board



Brad Gibson
Hull, UK

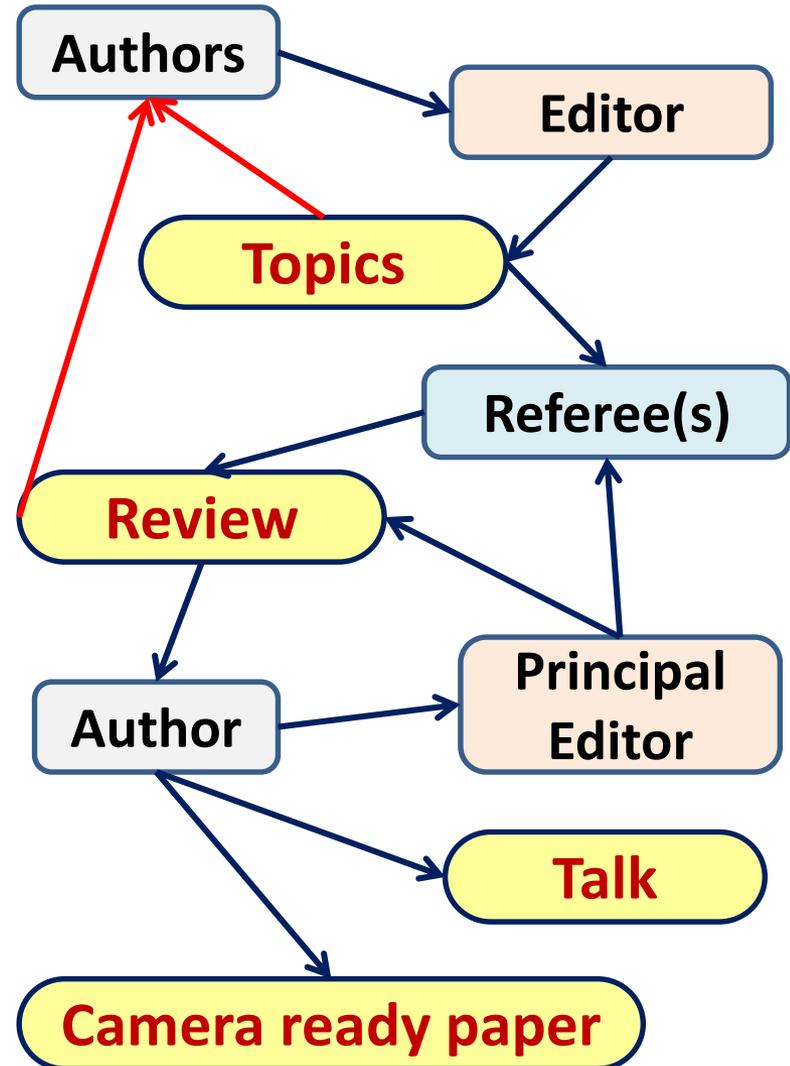


Igor Kulikov
Russia



Igor Chernykh
Russia

The Peer Review (ApJ-like)



Благодарность

Дорогие коллеги.

Поздравляю всех участников с успешным завершением второго симпозиума по численному моделированию в магнитной газодинамике и физике плазмы. Все докладчики и организаторы внесли большой вклад в развитие отечественной и мировой науки. Надеюсь, что данный симпозиум станет заметным явлением в научной жизни всего научного сообщества на многие десятилетия вперед.

С уважением,
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Институт прикладной математики им. М.В. Келдыша РАН,

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Механико-математический факультет,
МГУ им. М.В. Ломоносова

Фото конференции



Marchuk Scientific Readings

Third Workshop on Numerical Modeling in MHD and Plasma Physics: Methods, Tools, and Outcomes. Honor of Academician Guri. I. Marchuk 95th Birthday

October 7 – 9, 2020
Lake Teletskoye, Russia

