

SPIROS COTSAKIS

Mathematical Relativity | Dynamical Systems | Mathematical Cosmology

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Current affiliations: Clare Hall, University of Cambridge (Life Member), UK
Institute of Gravitation and Cosmology, RUDN University (Professor), Russia

Research areas: General relativity; dynamical systems; bifurcation & singularity theory; cosmology

Research profile

My work develops a unified dynamical-systems and singularity-theoretic framework for problems in general relativity and cosmology, with emphasis on nonhyperbolic transitions, organizing centers, versal unfoldings, and the geometry of bifurcation/discriminant sets (a “GR landscape” viewpoint). This approach extracts robust, model-independent structure from Einstein–matter systems (FRW fluids and scalar fields, modified gravity, horizons and singularities) and translates it into concrete qualitative diagnostics (classification diagrams, transition scenarios, stability/instability mechanisms, and normal-form reductions).

Appointments

- 2024–present: Clare Hall, University of Cambridge (Life Member), UK.
- 2023–2024: Clare Hall and DAMTP, University of Cambridge (Visiting Fellow), UK.
- 2020–present: Institute of Gravitation and Cosmology, RUDN University (Professor), Russia.
- 2007–2020: University of the Aegean, Greece (Professor).
- 2001–2007: University of the Aegean (Associate Professor).
- 1995–2001: University of the Aegean (Assistant Professor).
- 1992–1995: University of the Aegean (Lecturer / Assistant Professor under contract).
- Selected research visits: CERN Theory Division (Scientific Associate / Visiting Scientist), IHES (Visiting Fellow), Erwin Schrödinger Institute (Visiting Fellow), University of Liège (Visiting Fellow), NTUA (Visiting Research Professor), American University of the Middle East (affiliated with Purdue University) (Visiting Professor).

Education

- PhD in Mathematical Physics and Cosmology, University of Sussex, UK (1990).
- MSc in Astronomy, University of Sussex, UK (1987).
- BSc in Mathematics, University of Athens, Greece (1986).

Research directions (selected)

- **Singularity theory in GR/cosmology:** normal forms, versal unfoldings, and organizing centers for Einstein–matter dynamics.
- **Spacetime singularities and black holes:** bifurcation-diagram methods for singularity transitions; classification of asymptotics.
- **Horizon geometry and evolution:** geometric flows on null hypersurfaces (crease flow) and horizon-related dynamical phenomena.
- **FRW cosmologies:** dispersive synchronization mechanisms, qualitative structure of Friedmann–Lemaître models, transitions to cosmic acceleration, mode interactions in scalar field cosmology.
- **Modified gravity and scalarizations:** analytic structure, shocks/sudden transitions, and parameter-space geometry.

Publication summary

Total works: 124 (journal articles: 80; peer-reviewed conference proceedings: 29; edited volumes/theme issues: 7; other items: 8).

Selected publications (2023–2025; 10 items)

1. S. Cotsakis, *Dispersive Friedmann universes and synchronization*, *Gen. Rel. Grav.* 55 (2023) 61; arXiv:2208.07892.
2. S. Cotsakis, *Dynamical synchronization, the horizon problem, and initial conditions for inflation*, *Lett. High Energy Phys.* 322 (2023) 1; arXiv:2208.07104.
3. S. Cotsakis and J. Miritzis, *Trans-Planckian censorship and spacetime singularities*, *Mathematics* 11 (2023) 633; arXiv:2301.00156.
4. I. Antoniadis, S. Cotsakis, D. Trachilis, *Sudden shock waves in modified gravity*, *Eur. Phys. J. C* 83 (2023) 491; arXiv:2304.13291.
5. S. Cotsakis, *Bifurcation diagrams for spacetime singularities and black holes*, *Eur. Phys. J. C* 84:35 (2024) 1–38; arXiv:2311.16000.
6. S. Cotsakis, *The crease flow on null hypersurfaces*, *Eur. Phys. J. C* 84 (2024) 391; arXiv:2312.08023.
7. S. Cotsakis, *Friedmann–Lemaître universes and their metamorphoses*, *Eur. Phys. J. C* 85 (2025) 579; arXiv:2411.17286.
8. S. Cotsakis, *Structural Stability and General Relativity*, *Universe* 11 (7) (2025) 209; arXiv:2412.04283.
9. S. Cotsakis, *Cosmic acceleration as a saddle–node bifurcation: background identities and structure*, *Phil. Trans. R. Soc. A* (accepted); arXiv:2502.20430v2.

10. S. Cotsakis and I. Antoniadis, *Mode interactions in scalar field cosmology*, *Phil. Trans. R. Soc. A* (accepted); arXiv:2512.04607v2.

Selected earlier publications (representative)

1. J. D. Barrow and S. Cotsakis, *Inflation and the conformal structure of higher-order gravity theories*, *Phys. Lett. B* 214 (1988) 515–518.
2. J. D. Barrow and S. Cotsakis, *Chaotic behaviour in higher-order gravity theories*, *Phys. Lett. B* 232 (1989) 172–176.
3. S. Cotsakis, *Conformal transformations single out a unique measure of distance*, *Phys. Rev. D* 47 (1993) 1437–1439 (Erratum: D49 (1994) 1145).
4. S. Cotsakis and G. Flessas, *Stability of FRW cosmology in higher-order gravity*, *Phys. Rev. D* 48 (1993) 3577–3584.
5. S. Cotsakis and J. D. Barrow, *The dominant balance at cosmological singularities*, *J. Phys. Conf. Ser.* 68 (2007) 012004.
6. Y. Choquet-Bruhat and S. Cotsakis, *Global hyperbolicity and completeness*, *J. Geom. Phys.* 43 (2002) 345–350.
7. S. Cotsakis, R. Lemmer and P. G. L. Leach, *Adiabatic invariants and Mixmaster catastrophes*, *Phys. Rev. D* 57 (1998) 4691–4698.
8. S. Cotsakis and J. Miritzis, *Proof of the cosmic no-hair conjecture for some quadratic homogeneous models*, *Class. Quant. Grav.* 15 (1998) 2795–2801.
9. J. D. Barrow, S. Cotsakis, and A. Tsokaros, *A general sudden cosmological singularity*, *Class. Quant. Grav.* 27 (2010) 165017.
10. J. D. Barrow and S. Cotsakis, *Geodesics at sudden singularities*, *Phys. Rev. D* 88 (2013) 067301.

Additional selected publications (pre-2023)

1. S. Cotsakis and A. Saich, *Power-law inflation and conformal transformations*, *Class. Quant. Grav.* 11 (1994) 383–387.
2. S. Cotsakis, P. G. L. Leach, and G. Flessas, *Minimally coupled scalar-field wormholes*, *Phys. Rev. D* 49 (1994) 6489–6492.
3. S. Cotsakis and G. Flessas, *Past-instability conjecture and cosmological attractors in generalized gravity*, *Phys. Rev. D* 51 (1995) 4160–4168.
4. S. Cotsakis and G. Flessas, *Graviton creation and conformal non-invariance in higher-order gravity*, *Phys. Rev. D* 52 (1995) 5783–5786.
5. S. Cotsakis and L. G. Querella, *Variational and conformal structure of nonlinear metric-connection gravity*, *J. Math. Phys.* 40 (1999) 3063–3071.

6. S. Cotsakis, *Global hyperbolicity of sliced spaces*, *Gen. Rel. Grav.* 36 (2004) 1183–1188.
7. I. Antoniadis, S. Cotsakis, and I. Klaoudatou, *Brane singularities and their avoidance*, *Class. Quant. Grav.* 27 (2010) 235018.
8. S. Cotsakis and G. Kittou, *Flat limits of curved interacting cosmic fluids*, *Phys. Rev. D* 88 (2013) 083514.
9. J. D. Barrow, S. Cotsakis, and A. Tsokaros, *Geodesics at sudden singularities*, *Phys. Rev. D* 88 (2013) 067301.
10. S. Cotsakis, *Onset of synchronization in coupled Mixmaster oscillators*, *Phil. Trans. R. Soc. A* 380 (2022) 20210189; arXiv: 2010.00298.

Edited volumes and theme issues

- *Global Structure and Evolution in General Relativity* (with G. W. Gibbons, eds.), Springer LNP 460 (1996).
- *Mathematical and Quantum Aspects of Relativity and Cosmology* (with G. W. Gibbons, eds.), Springer LNP 537 (2000).
- *Cosmological Crossroads* (with E. Papantonopoulos, eds.), Springer LNP 592 (2002).
- *Theoretical and Observational Cosmology* (with M. Plionis, eds.), Kluwer ASSL 276 (2002).
- *Eleventh Conference on Recent Developments in Gravity* (with J. Miritzis, eds.), *J. Phys. Conf. Ser.* 8 (2005).
- *The future of mathematical cosmology* (with A. P. Yefremov, eds.), *Phil. Trans. R. Soc. A* 380 (2022) Theme Issues 2222, 2230.
- *Dynamical Systems and Stability in Gravitation and Cosmology* (with A. P. Yefremov, eds.), *Phil. Trans. R. Soc. A* (upcoming Theme Issue, 2026).

Teaching and supervision (selected)

Courses taught: Calculus (I–IV), linear algebra, ODEs/PDEs, differential geometry, classical mechanics, classical field theory, general relativity and cosmology; postgraduate courses include analysis, modelling, and advanced methods in relativity/cosmology.

Advanced lecture series / mini-courses (selected):

- Minicourse on *Geometric Flows*, University of Hamburg, 2016.
- 3-lecture course on *The Ambient Metric*, NTUA (Athens), 2014.
- Week-long courses at the University of the Aegean: *Spacetime Singularities* (2001); *Mathematical Relativity* (1996); *Mathematical Cosmology* (1995); *Advanced Geometric Methods in Mathematical Physics* (1994).

PhD supervision (advisor, University of the Aegean):

- J. Miritzis (1997), I. Klaoudatou (2008), G. Kittou (2015), G. Kolionis (2016), D. Trachilis (2016), F. Argiana (2021).

Service, editorial work, and administration (selected)

- Founder and Director, *Laboratory of Geometry, Dynamical Systems and Cosmology* (University of the Aegean; founded 1998).
- Department administration (University of the Aegean): Deputy Head (2005–2009), Head (2009–2013), Senate Member (2009–2013), Head of Postgraduate Studies (2010–2013), and related committee service.
- Editorial board member: *Mathematics* (2021–2023); *Astronomy* (2021–present).
- Refereeing for: *Mathematical Reviews*, *PRD*, *PRL*, *Physics Letters B*, *CQG*, *JMP*, *J. Phys. A*, *GRG*, *J. Geom. Phys.*, *EPJC*, and others.

Conference and school organization (selected)

- Chair, Parallel Session “Topological Methods, Global Existence Problems, and Spacetime Singularities”, Marcel Grossmann 16 (Rome, 2021).
- Chair, Parallel Sessions “Cosmological Singularities and Asymptotics”, Marcel Grossmann 14 (Rome, 2015), MG13 (Stockholm, 2012), MG12 (Paris, 2009), MG11 (Berlin, 2006).
- Organizer/co-organizer: Aegean Summer Schools and workshops on cosmology/relativity (Samos, 1990s–2000s), and related Hellenic cosmology workshops and meetings.

Selected invited talks / lectures (representative)

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| • MDPI Online Workshop on Dark Energy (invited), 2025. | • Regional Meeting on String Theory, 2015. |
| • IGC/RUDN, Moscow, 2024. | • NTUA School of Applied Mathematics & Physical Sciences, 2014. |
| • Aegean School (Syros), 2022. | • Marcel Grossmann 13 (Rapporteur), 2012. |
| • University of Lisbon, 2022. | • Marcel Grossmann 12 (Rapporteur), 2009. |
| • Marcel Grossmann 16 (Rapporteur), 2021. | • Marcel Grossmann 11 (Rapporteur), 2006. |
| • University of Hamburg Summer School (plenary), 2016. | • Greek Relativity Meeting, 2008. |
| • Marcel Grossmann 14, 2015. | • AUM research seminar series, 2018. |
| | • Further invited talks listed in the full CV. |

Full publication list: available as a separate document.