

SPIROS COTSAKIS

Mathematical Relativity | Dynamical Systems | Mathematical Cosmology

Email: skot@aegean.gr

Web: spiroscotsakis.com

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.
- 2015–2020: American University of the Middle East (affiliated with Purdue University), Kuwait (Professor).
- 2014–2015: National Technical University of Athens, Greece (Visiting Research Professor).
- 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), IHS (Visiting Fellow), Erwin Schrödinger Institute (Visiting Fellow), University of Liège (Visiting Fellow).

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.