Roberto Soria — Curriculum Vitae

Citizenship: Italian
Languages: English, Piedmontese, Italian, French
Postal Address: Mullard Space Science Laboratory (UCL)
Holmbury St Mary, Dorking, Surrey, RH5 6NT, United Kingdom
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Education and career

2008–current: Leverhulme Fellow, University College London

2004–2008: Marie Curie Fellow, Harvard-Smithsonian Center for Astrophysics (from 2004 Aug to 2007 Feb) & University College London (2007 Mar – 2008 Feb)

2000–2004: Research Fellow, Mullard Space Science Laboratory, University College London

1995–1999: PhD student at the Research School of Astronomy & Astrophysics, Australian National University
Dissertation: "Accretion Processes in Black-Hole Binaries"
Supervisor: Dr. Kinwah Wu (University of Sydney)

1989–1994: BSc + Honours degree in Physics (110 *cum laude*, highest score), University of Turin.
Thesis: "Space-time Measurements in the Gravitational Field of a Kerr Black Hole"
Supervisor: Prof. Fernando de Felice (University of Padova)

Fellowships and Scholarships

Chinese Academy of Sciences Research Fellowship (2010)
Leverhulme Fellowship (2008–2010), funded by the Leverhulme Trust
UK-China Fellowship for Excellence (2008), funded by the UK government
Sydney University Visiting Fellowship (2007)
Marie Curie Fellowship (2004–2008), funded by the European Union
Chandra X-ray Center research grant (2006), funded by NASA
Overseas Postgraduate Research Scholarship (1995–1999), funded by the Australian Government
ANU Scholarship (1995–1999)

Membership of Professional Societies

Astronomical Society of Australia
Royal Astronomical Society

Research track record

As of December 2009, I have 65 refereed publications (31 of them as first author) in the major astrophysical journals, with 3 other papers currently submitted or in press (list available on ADS). They have attracted over 1000 citations. Over the last four years, I have 30 refereed publications (11 of them as first author). My h–index is 19.

Teaching experience

Both my Marie Curie and my Leverhulme fellowships were for research only, and did not allow me to take up teaching of a regular course or be the official primary supervisor of PhD students. However, I have been happy to teach several units of the High-Energy Astrophysics and Special Relativity 3rd-year courses at University College London in support of other lecturers. This semester, I am giving a series of postgraduate lectures on theoretical and astrophysical properties of black holes at the Mullard Space Science Laboratory. I also give lectures for continuing education and UCL science diploma courses.

Student supervision

Co-supervisor of Mr Weiming Zhang (PhD 2009, Tsinghua University)
Advisor of Mr Fabien Grise' (PhD 2008, Strasbourg Observatory)
Advisor of Mr Chris Copperwheat (PhD 2007, University College London)
Advisor of Ms Rhaana Starling (PhD 2005, University College London)
Supervisor or Mr Nicholas Scott (MSc 2004, University College London)
Advisor of Mr Calvin Hung (MSc 2007, Sydney University)

Roberto Soria — Refereed publications

1. “Discovery of an optical counterpart to the hyperluminous X-ray source in ESO 243-49”,
Soria, R., Hau, G. K. T., Graham, A. W., Kong, A. K. H. Kong, Kuin, N. P. M., Li, I-H., Liu, J.-F., & Wu, K. **2009**, submitted to Mon. Not. R. Astron. Soc. (arXiv0910.1356)

2. “An X-ray view of star formation in the central 3 kpc of NGC 2403”,
Yukita, M., Swartz, D. A., Tennant, A. F., & Soria, R. **2009**, accepted by Astrophys. J. (arXiv:0912.5135)

3. “Ultraluminous X-ray source correlations with star-forming regions”,
Swartz, D. A., Tennant, A. F., & Soria, R. **2009**, Astrophys. J., 703, 159.

4. “AGN/starburst connection in action: the half million second RGS spectrum of NGC 1365”,
Guainazzi, M., Risaliti, G., Nucita, A., Wang, J., Bianchi, S., Soria, R., & Zezas, A. **2009**, Astron. & Astrophys., 505, 589.

5. “A census of X-ray nuclear activity in nearby galaxies”,
Zhang, W. M., Soria, R., Zhang, S. N., Swartz, D. A., & Liu, J. F. **2009**, Astrophys. J., 699, 281.

6. “Different types of ultraluminous X-ray sources in NGC 4631”,
Soria, R., & Ghosh, K. K. **2009**, Astrophys. J., 696, 287.

7. “Variable partial covering and a relativistic iron line in NGC 1365”,
Risaliti, G., Miniutti, G., Elvis, M., Fabbiano, G., Salvati, M., Baldi, A., Braito, V., Bianchi, S., Matt, G., Reeves, J., Soria, R., & Zezas, A. **2009**, Astrophys. J., 696, 160.

8. “The *XMM-Newton* long look of NGC 1365: lack of a high/soft state in its ultraluminous X-ray sources”’
Soria, R., Risaliti, G., Elvis, M., Fabbiano, G., Bianchi, S., & Kuncic, Z. **2009**, Astrophys. J., 695, 1614.

9. “An anticorrelation between X-ray luminosity and Hα equivalent width in X-ray binaries”,
Fender, R. P., Russell, D. M., Knigge, C., Soria, R., Hynes, R. I., & Goad, M. **2009**, Mon. Not. R. Astron. Soc., 393, 1608.

10. “The XMM-Newton long look of NGC 1365: uncovering of the obscured X-ray source”,
Risaliti, G., Salvati, M., Elvis, M., Fabbiano, G., Baldi, A., Bianchi, S., Braito, V., Guainazzi, M., Matt, G., Miniutti, G., Reeves, J., Soria, R., & Zezas, A. **2009**, Mon. Not. R. Astron. Soc., 393, L1.

11. “Do Ultraluminous X-Ray Sources Exist in Dwarf Galaxies?”,
Swartz, D. A., Soria, R., & Tennant, A. F. **2008**, Astrophys. J., 684, 282.

12. “The oldest X-ray supernovae: X-ray emission from 1941C, 1959D, 1968D”,
Soria, R., & Perna, R. **2008**, Astrophys. J., 683, 767.

13. “The ultraluminous X-ray source NGC 1313 X-2: its optical counterpart and environment”,
Grisé, F., Pakull, M. W., Soria, R., Motch, C., Smith, I. A., Ryder, S. D., & Böttcher, M. **2008**, Astron. & Astrophys., 486, 151.

14. “How rapidly do neutron stars spin at birth? Constraints from archival X-ray observations of extragalactic supernovae”,
Perna, R., Soria, R., Pooley, D., & Stella, L. **2008**, Mon. Not. R. Astron. Soc., 384, 1638.

15. “Black hole mass estimates from soft X-ray spectra”,
Soria, R., & Kuncic, Z. **2008**, Adv. Sp. Research, 42, 517.

16. “A Deep Chandra, Very Large Array, and Spitzer Infrared Array Camera Study of the Very Low Luminosity Nucleus of the Elliptical NGC 821”,
Pellegrini, S., Siemiginowska, A., Fabbiano, G., Elvis, M., Greenhill, L., Soria, R., Baldi, A., & Kim, D. W. **2007**, Astrophys. J., 667, 749.

17. “A Deep Chandra Look at the Low-L_B Elliptical NGC 821: X-Ray Binaries, a Galactic Wind, and Emission at the Nucleus”,
Pellegrini, S., Baldi, A., Kim, D. W., Fabbiano, G., Soria, R., Siemiginowska, A., & Elvis, M. **2007**, Astrophys. J., 667, 731.

18. “New flaring of an ultraluminous X-ray source in NGC1365”,
Soria, R., Baldi, A., Risaliti, G., Fabbiano, G., King, A., La Parola, V., & Zezas, A. **2007**, Mon. Not. R. Astron. Soc., 379, 1313.

19. “Bridging the gap between stellar-mass black holes and ultraluminous X-ray sources”,
Soria, R. **2007**, Astrop. & Sp. Science, 311, 213.

20. “Discovery of a transient X-ray source in the compact stellar nucleus of NGC 2403”,
Yukita, M., Swartz, D. A., Soria, R., & Tennant, A. F. **2007**, Astrophys. J., 664, 277.

21. “Irradiation models for ULXs and fits to optical data”,
Copperwheat, C., Cropper, M., Soria, R., & Wu, K. **2007**, Mon. Not. R. Astron. Soc., 376, 1407.

22. “Quasi-periodic variability in NGC 5408 X-1”,
Strohmayer, T. E., Mushotzky, R. F., Winter, L., Soria, R., Uttley, P., & Cropper, M. **2007**, Astrophys. J., 660, 580.

23. “Latest results on Jovian disk X-rays from *XMM-Newton*”,
Branduardi-Raymont, G., Bhardwaj, A., Elsner, R. F., Gladstone, G. R., Ramsay, G., Rodriguez, P., Soria, R., Waite, J. H., Jr, Cravens, T. E. **2007**, Plan. & Space Sc., 55, 1126.

24. “A study of Jupiter’s aurorae with *XMM-Newton*”,
Branduardi-Raymont, G., Bhardwaj, A., Elsner, R. F., Gladstone, G. R., Ramsay, G., Rodriguez, P., Soria, R., Waite, J. H., Jr, Cravens, T. E. **2007**, Astron. & Astrophys., 463, 761.

25. “A ULX associated with a cloud collision in M 99”,
Soria, R., & Wong, D. S. **2006**, Mon. Not. R. Astron. Soc., 372, 1531.

26. “On the weakness of disc models in bright ULXs”,
Gonçalves, A. C., & Soria, R. **2006**, Mon. Not. R. Astron. Soc., 371, 673.

27. “Discovery of two ULXs in NGC 7424”,
Soria, R., Kuncic, Z., Broderick, J., & Ryder, S. **2006**, Mon. Not. R. Astron. Soc., 370, 1666.

28. “Radio and X-ray Properties of Relativistic Beaming Models for Ultra-Luminous X-ray Sources”,
Freeland, M., Kuncic, Z., Soria, R., & Bicknell, G. V. **2006**, Mon. Not. R. Astron. Soc., 372, 630.

29. “A ULX microquasar in NGC 5408?”,
Soria, R., Fender, R. P., Hannikainen, D. C., Read, A. M., & Stevens, I. R. **2006**, Mon. Not. R. Astron. Soc., 368, 1527.

30. “*Chandra* observations of circum-nuclear star formation in NGC 3351”,
Swartz, D. A., Yukita, M., Tennant, A. F., Soria, R., & Ghosh, K. K. **2006**, Astrophys. J., 647, 1030.

31. “Accretion and nuclear activity of quiescent supermassive black holes—II: optical study and interpretation”,
Soria, R., Graham, A. W., Fabbiano, G., Baldi, A., Elvis, M., Jerjen, H., Pellegrini, S., & Siemiginowska, A. **2006**, Astrophys. J., 640, 143.

32. “Accretion and nuclear activity of quiescent supermassive black holes—I: X-ray study”,
Soria, R., Fabbiano, G., Graham, A. W., Baldi, A., Elvis, M., Jerjen, H., Pellegrini, S., & Siemiginowska, A. **2006**, Astrophys. J., 640, 126.

33. “Optical and infrared signatures of ultraluminous X-ray sources”,
Copperwheat, C., Cropper, M., Soria, R., & Wu, K. **2005**, Mon. Not. R. Astron. Soc., 362, 79.

34. “The star-forming environment of an ultraluminous X-ray source in NGC 4559: an optical study”,
Soria, R., Cropper, M. S., Pakull M., Mushotzky, R. F., & Wu, K. **2005**, Mon. Not. R. Astron. Soc., 356, 12.

35. “The Seyfert-LINER galaxy NGC 7213: an *XMM-Newton* Observation”,
Starling, R. L. C., Page, M. J., Branduardi-Raymont, G., Breeveld, A. A., Soria, R., & Wu, K. **2005**, Astrophys. & Space Sc., 300, 81.

36. “Solar control on Jupiter’s equatorial X-ray emissions: 26–29 Nov 2003 *XMM-Newton* observation”,
Bhardwaj, A., Branduardi-Raymont, G., Elsner, R. F., Gladstone, G. R., Ramsay, G., Rodriguez, P., Soria, R., Waite, J. H., & Cravens, T. E. **2005**, Geophys. Res. Lett. 32, 3, S08.

37. "Classifying the zoo of ultraluminous sources",
Soria, R., Cropper, M. S., & Motch, C. **2005**, Chinese J. Astron. Astrophys., 5, 153.

38. "The X-ray spectrum of NGC 7213 and the Seyfert-LINER connection",
Starling, R. L. C., Page, M. J., Branduardi-Raymont, G., Breeveld, A. A., Soria, R., & Wu, K. **2005**, Mon. Not. R. Astron. Soc., 356, 727.

39. "First Observations of Jupiter by *XMM-Newton*",
Branduardi-Raymont, G., Elsner, R. F., Gladstone, G. R., Ramsay, G., Rodriguez, P., Soria, R., & Waite, J. H. **2004**, Astron. & Astrophys., 424, 331.

40. "X-ray flares from the ultraluminous X-ray source in NGC 5408",
Soria, R., Motch, C., Read, A. M., & Stevens, I. R. **2004**, Astron. & Astrophys., 423, 955.

41. "A variable ultraluminous X-ray source in the colliding galaxy NGC 7714",
Soria, R., & Motch, C. **2004**, Astron. & Astrophys., 422, 915.

42. "Highly ionised Fe Kα emission lines from the LINER galaxy M 81",
Page, M. J., Soria, R., Zane, S., Wu, K., & Starling, R. L. C. S. **2004**, Astron. & Astrophys., 422, 77.

43. "Probable intermediate mass black holes in NGC 4559: *XMM-Newton* spectral and timing constraints",
Cropper, M. S., Soria, R., Mushotzky, R. F., Wu, K., Markwardt, C. B., & Pakull M. **2004**, Mon. Not. R. Astron. Soc., 349, 39.

44. "Constraints on AGN accretion disk viscosity derived from continuum variability",
Starling, R. L. C., Siemiginowska, A., Uttley, P., & Soria, R. **2004**, Mon. Not. R. Astron. Soc., 347, 67.

45. "A second glance at SN 2002ap and the M 74 field with *XMM-Newton*",
Soria, R., Pian, E., & Mazzali, P. A. **2004**, Astron. & Astrophys., 413, 107.

46. "Properties of discrete X-ray sources in the starburst spiral galaxy M 83",
Soria, R., & Wu, K. **2003**, Astron. & Astrophys., 410, 53.

47. "*XMM-Newton* RGS spectroscopy of LMC X-3",
Page, M. J., Soria, R., Wu, K., Mason, K. O., Cordova, F. A., & Priedhorsky, W. C. **2003**, Mon. Not. R. Astron. Soc., 345, 639.

48. "X-ray emission-line gas in the LINER galaxy M 81",
Page, M. J., Breeveld, A. A., Soria, R., Wu, K., Branduardi-Raymont, G., Mason, K. O., Starling, R. L. C. S., & Zane, S. **2003**, Astron. & Astrophys., 400, 145.

49. "*XMM-Newton* observations of the spiral galaxy M 74 (NGC 628)",
Soria, R., & Kong, A. K. H. **2002**, Astrophys. J., 572, L33.

50. "X-ray sources in the starburst spiral galaxy M 83: nuclear region and discrete source population",
Soria, R., & Wu, K. **2002**, Astron. & Astrophys., 384, 99.

51. "The 1998 outburst of XTE J1550−564: a model based on multiwavelength observations",
Wu, K., Soria, R., Campbell-Wilson, D., Hannikainen, D. C., Harmon, A., Hunstead, R. W., Johnston, H. M., McCollough, M., & McIntyre, V. **2002**, Astrophys. J., 565, 1161.

52. "An irradiated accretion disk in the narrow-line Seyfert 1 RE J1034+396?",
Soria, R., & Puchnarewicz, E. M. **2002**, Mon. Not. R. Astron. Soc., 329, 456.

53. "The central region of M31 observed with XMM-Newton (II): variability of the individual sources",
Osborne, J. P., Borozdin, K. N., Trudolyubov, S. P., Priedhorsky, W. C., Soria, R., Shirey, R., Hayter, C., La Palombara, N., Mason, K., Molendi, S., Paerels, F., Pietsch, W., Read, A. M., Tiengo, A., Watson, M. G., & West, R. G. **2001**, Astron. & Astrophys., 378, 800.

54. "XMM-Newton Optical Monitor observations of LMC X-3",
Soria, R., Wu., K., Page, M., & Sakelliou, I. **2001**, Astron. & Astrophys., 365, L273.

55. "XMM-Newton EPIC and RGS observations of LMC X-3",
Wu, K., Soria, R., Page, M., Sakelliou, I., Kahn, S. M., & de Vries, C. P. **2001**, Astron. & Astrophys., 365, L267.

56. “The central region of M31 observed with XMM-Newton (I): group properties and diffuse emission”, Shirey, R., Soria, R., Borozdin, K., Osborne, J. P., Tiengo, A., Guainazzi, M., Hayter, C., La Palombara, N., Mason, K., Molendi, S., Paerels, F., Pietsch, W., Priedhorsky, W., Read, A. M., Watson, M. G., & West, R. G. **2001**, Astron. & Astrophys., 365, L195.

57. “Optical spectroscopy of GX 339−4 during the high-soft and low-hard states: II: line ionisation and emission region”, Wu, K., Soria, R., Hunstead, R. W., & Johnston, H. M. **2001**, Mon. Not. R. Astron. Soc., 320, 177.

58. “Optical spectroscopy of GRO J1655−40”, Soria, R., Wu, K., & Hunstead, R. W. **2000**, Astrophys. J., 539, 445.

59. “Optical counterpart of the X-ray transient RX J0117.6−7330: spectroscopy and photometry”, Soria, R. **1999**, Publ. Astr. Soc. Australia, 16, 147.

60. “A study of the new X-ray transient RXTE J2123−058 during its post-outburst state”, Soria, R., Wu, K., & Galloway, D. **1999**, Mon. Not. R. Astron. Soc., 309, 528.

61. “Optical spectroscopy of GX 339−4 during the high-soft and low-hard states: I”, Soria, R., Wu, K., & Johnston, H. M. **1999**, Mon. Not. R. Astron. Soc., 310, 71.

62. “Optical lines from the black-hole binary GRO J1655−40”, Soria, R. **1998**, Publ. Astr. Soc. Australia, 15, 242.

63. “Measuring the mass of the black hole in GRO J1655−40”, Soria, R., Wickramasinghe, D. T., Hunstead, R. W., & Wu, K. **1998**, Astrophys. J., 495, L95.

64. “Effects of magnetized winds on advective disks”, Soria, R., Li, J., & Wickramasinghe, D. T. **1997**, Astrophys. J., 487, 769.

65. “Detection of the tip of the Red Giant Branch in NGC 5128”, Soria, R., Mould, J. R., Watson, A. M., Gallagher, J. S., III, Ballester, G. E., Burrows, C. J., Casertano, S., Clarke, J. T., Crisp, D., Griffiths, R. E., Hester, J. J., Hoessel, J. G., Holtzman, J. A., Scowen, P. A., Stapelfeldt, K. R., Trauger, J. T., & Westphal, J. A. **1996**, Astrophys. J., 465, 79.

Recent conference participation (2006–present)

— Invited speaker at the workshop ”Ultra-Luminous X-ray sources and Middle Weight Black Holes”, ESAC, Madrid, May 2010.
— Invited speaker to the Royal Astronomical Society specialist discussion meeting, “The X-Ray Astronomy Revolution: The Ongoing Impact of XMM-Newton and Chandra”, London, 8 Jan 2010.
— Invited speaker to the TIARA international workshop on AGN and star formation, Tsing Hua University, Taiwan, Nov 2009.
— Member of the SOC and contributing speaker for the conference ”Chandra’s First Decade of Discovery”, Boston, Sep 2009.
— Invited speaker at the workshop ”Black Holes in Binary Systems”, Ferrara, Italy, Sep 2009.
— Contributing speaker at the conference ”X-Ray Astronomy 2009”, Bologna, Italy, Sep 2009.
— Invited speaker at the 12th Marcel Grossmann Meeting on General Relativity (Parallel session: X-ray observations from space), Paris, Jul 2009.
— Contributing speaker at the workshop ”Intermediate-Mass Black Holes: from First Light to Galactic Nuclei”, University of California Irvine, Apr 2009.
— Invited speaker at the 10th Asia-Pacific Regional IAU Meeting, Kunming, China, Aug 2008.
— Invited speaker at the conference ”Observational Evidence of Black Holes”, Kolkata, India, Feb 2008.
— Invited speaker at the workshop ”X-Rays from Nearby Galaxies”, ESAC, Madrid, Spain, Sep 2007.
— Contributing speaker at the conference ”X-ray Surveys: Evolution of Accretion, Star-Formation and the Large Scale Structure”, Rhodes, Greece, Jul 2007.
— Contributing speaker at the 23rd Texas Symposium on Relativistic Astrophysics, Melbourne, Australia, Dec 2006.
— Member of the SOC and contributing speaker for the 5th Stromlo Symposium: ”Disks, Winds & Jets from Planets to Quasars”, ANU, Canberra, Australia, Dec 2006.
— Contributing speaker at the 26th IAU General Assembly (IAU Symposium 238), Prague, Aug 2006.
— Contributing speaker at the 36th COSPAR Meeting, Beijing, Jul 2006.
— Contributing speaker at the 11th Marcel Grossmann Meeting on General Relativity (Parallel session: astrophysical black hole theory), Berlin, Jul 2006.

Conference papers

1. “Radio lobes and X-ray hot spots of the extraordinary microquasar in NGC 7793”,
   Soria, R., Pakull, M. W., Broderick, J., Corbel, S., & Motch, C. **2009**, Proceedings of the conference “X-ray Astronomy 2009”, Bologna (Italy), September 2009, in press (arXiv0912.2732).

2. “The ULX NGC 1313 X-2 : an optical study revealing an interesting behavior”,
   Grisé, F., Pakull, M. W., Soria, R., & Motch, C. **2009**, Proceedings of the 2nd Simbol-X International Symposium ”Simbol-X: Focusing on the Hard X-ray Universe”, AIP Conf. Proc. Series, P. Ferrando and J. Rodriguez eds, in press (arXiv:0902.4431).

3. “How rapidly do neutron stars spin at birth?”,
   Soria, R., Perna, R., Pooley, D., & Stella, L. **2008**, Proceedings of the 10th Asia-Pacific Regional IAU Meeting, Kunming (China), August 2008, p. 258 (arXiv:0811.3605).

4. “Black hole masses in ultraluminous X-ray sources”,
   Soria, R. **2008**, Proceedings of the 11th Marcel Grossmann Meeting on General Relativity, Berlin, July 2006, eds. H. Kleinert, R. T. Jantzen, R. Ruffini, World Scientific, in press.

5. “Black hole masses and accretion states in ULXs”,
   Soria, R., & Kuncic, Z. **2008**, Proceedings of the conference ”Observational Evidence of Black Holes”, Kolkata (India), February 2008, AIP Conf. Proc. Series 1053, 103 (arXiv:0807.0016).

6. “Characteristic temperatures and spectral appearance of ULX disks”,
   Soria, R., Wu, K., & Kuncic, Z. **2008**, Proceedings of the ESAC faculty workshop ”X-rays from Nearby Galaxies”, European Space Agency, ESAC (Madrid), September 2007, Max-Planck-Institut für extraterrestrische Physik, MPE Report 295, p.48 (arXiv/0711.2448).

7. “X-ray study of star formation in NGC 2403”,
   Yukita, M., Swartz, D., & Soria, R. **2008**, Proceedings of the ESAC faculty workshop ”X-rays from Nearby

Galaxies", European Space Agency, ESAC (Madrid), September 2007, Max-Planck-Institut für extraterrestrische Physik, MPE Report 295, p.149.

8. "Thermal and Non-Thermal Components of the X-Ray Emission from Jupiter",
Branduardi-Raymont, G., Bhardwaj, A., Elsner, R. F., Gladstone, G. R., Ramsay, G., Rodriguez, P., Soria, R., Waite, J. H., Jr., & Cravens, T. E. **2007**, Progress of Theoretical Physics Supplement, 169, 75.

9. "Soft-excess in ULX spectra: disc emission or wind absorption?",
Gonçalves, A. C., & Soria, R., **2007**, Proceedings of "The Multicoloured Landscape of Compact Objects and their Explosive Progenitors: Theory vs Observations", Cefalú (Sicily), June 11-24, 2006 (AIP), 924, 919.

10. "Soft-excess in ULX spectra: the chilled-disk scenario",
Soria, R., Gonçalves, A. C., & Kuncic, Z. **2007**, Proceedings of "The Multicoloured Landscape of Compact Objects and their Explosive Progenitors: Theory vs Observations", Cefalú (Sicily), June 11-24, 2006 (AIP), 924, 741.

11. "A ULX and a giant cloud collision in M 99",
Soria, R., & Wong, D. S. **2007**, Proceedings of the International Astronomical Union Symposium 238, Prague, August 2006, 455.

12. "Chilled disks in ultraluminous X-ray sources",
Soria, R., Kuncic, Z., & Gonçalves, A. C. **2007**, Proceedings of the International Astronomical Union Symposium 238, Prague, August 2006, 453.

13. "On the nature of ultraluminous X-ray sources from optical/IR measurements",
Cropper, M., Copperwheat, C., Soria, R., & Wu, K. **2007**, Proceedings of the International Astronomical Union Symposium 238, Prague, August 2006, 251.

14. "Ultraluminous X-ray sources: X-ray binaries in a high/hard state?",
Kuncic, Z., Soria, R., Hung, C. K., Freeland, M. C., & Bicknell, G. V. **2007**, Proceedings of the International Astronomical Union Symposium 238, Prague, August 2006, 247.

15. "Recipes for ULX formation: necessary ingredients and garnishments",
Soria, R. **2007**, Proceedings of the International Astronomical Union Symposium 238, Prague, August 2006, 235.

16. "X-ray binaries in the Fornax Local Group Dwarf",
Kilgard, R. E., Soria, R., Prestwich, A. H., & Kalogera, V. **2006**, American Astronomical Society Meeting 209, 155.02

17. "XMM-Newton observations of X-ray emission from Jupiter",
Branduardi-Raymont, G., Bhardwaj, A., Elsner, R. F., Gladstone, G. R., Ramsay, G., Rodriguez, P., Soria, R., Waite, J. H., Jr, & Cravens, T. E. **2006**, Proceedings of The X-ray Universe 2005, El Escorial (Spain), September 2005, ESA SP-604, ed. A. Wilson, p.15 (astro-ph/0512249).

18. "Why are they not AGN",
Soria, R., et al. **2006**, Proceedings of The X-ray Universe 2005, El Escorial (Spain), September 2005, ESA SP-604, ed. A. Wilson, p. 671.

19. "Irradiation models for ultra-luminous X-ray sources and fits to HST data",
Copperwheat, C., Cropper, M., Soria, R., & Wu, K. **2006**, Proceedings of The X-ray Universe 2005, El Escorial (Spain), September 2005, ESA SP-604, ed. A. Wilson, p.257 (astro-ph/0512249).

20. "Protostellar mergers in protoclusters and the origin of ultra-luminous X-ray sources",
Soria, R. **2006**, Proceedings of the IAU Symposium 230, Dublin (Ireland), August 2005, p.473 (astro-ph/0509573).

21. "Dwarf galaxies of the Local Group",
Di Stefano, R., Soria, R., Primini, F., & Kong, A. **2006**, Proceedings of the IAU Symposium 230, Dublin (Ireland), August 2005, p.164 (astro-ph/0606363).

22. "Runaway core collapse and cluster survival: where are the parent clusters of ULXs?",
Soria, R. **2005**, Proceedings of the XXII Texas Symposium on Relativistic Astrophysics, Stanford University, December 2004 (astro-ph/0503340).

23. “X-ray emission from Jupiter as observed with *XMM-Newton*”,
Branduardi-Raymont, G., et al. **2005**, American Geophys. Union, Spring Meeting, P44A-02.

24. “Intermediate-mass black holes in late-type disk galaxies”,
Soria, R. **2004**, in the Federation Fellowship Symposium, Canberra, November 2004,
http://www.atnf.csiro.au/research/conferences/ffsymp2004/talks/soria.pdf

25. “Auroral and non-auroral X-ray emissions from Jupiter: a comparative view”,
Bhardwaj, A., et al. **2004**, American Geophysical Union, Fall Meeting, P51B-1432.

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Research Interests

My ultimate goal is to establish the black-hole mass spectrum and energy budget on scales extending from stars to galaxies. I want to distinguish between different classes of astrophysical black holes, originating either from individual stellar collapses, or coalescence processes in dense systems, or grown via accretion in galactic nuclei. In parallel, I want to determine what fraction of their accretion power is released as radiation or mechanical energy as a function of black hole mass and accretion rate. To achieve those goals, I do multiband observational studies and phenomenological modelling of accreting black holes, with particular emphasis on non-nuclear sources with accretion power $P_w \gtrsim$ a few $\times 10^{40}$ erg s^{-1}. Throughout my career, I have investigated the spectral states and time variability of accreting black holes, the mass transfer from the donor star or the surrounding gas, the properties of the host stellar environment, and the energy injection from the accreting black hole into the environment (e.g., ionized bubbles around ultraluminous X-ray sources).

For my PhD thesis (supervisor: Prof. K. Wu), I carried out optical spectroscopic and photometric studies of **Galactic X-ray binaries** (in particular, the BH soft X-ray transients GRO J1655−40: Soria et al. 1998, Soria, Wu & Hunstead 2000; GX339-4: Soria, Wu & Johnston 1999, Wu et al. 2001a; XTE J1550−564: Wu et al. 2002). I used phase-resolved spectroscopy to determine the mass of the BH, and constrain the properties of the accretion flow in the outer disk and near the irradiated surface of the companion star. I modelled the effect of soft and hard X-ray irradiative heating on the surface of the outer disk.

During my research appointments at the Mullard Space Science Laboratory (University College London) and at the Harvard-Smithsonian Center for Astrophysics, I focused on the **X-ray properties of accreting BHs**. I carried out studies of individual sources (for example LMC X-3: Soria et al. 2001, Wu et al. 2001b, Page et al. 2003a), as well as population studies in the context of the properties of their **host galaxies**. I used X-ray colours and luminosities to identify different classes of point-like X-ray sources (accreting BHs and neutron stars; young supernova remnants; nuclear-burning white dwarfs) in star-forming galaxies (eg, M 31: Shirey et al. 2001; M 74: Soria & Kong 2002; Soria, Pian & Mazzali 2004; M 83: Soria & Wu 2002,2003). I studied the luminosity distribution of those populations, and their spatial distribution and association with star-forming regions (Swartz, Soria & Tennant 2008; Swartz, Tennant & Soria 2009). The significance of this research is that we can use population studies of different classes of discrete X-ray sources to improve our understanding of star-formation activity and evolution of the host galaxy, in parallel with optical population studies of the stellar component.

Over the last few years, I have focused on the most luminous and still unexplained class of accreting compact remnants, known as **ultraluminous X-ray sources (ULXs)**. I have carried out detailed studies of such sources in several galaxies (eg, M 99: Soria & Wong 2006; NGC 5408: Soria et al. 2004,2006c; NGC 1365: Soria et al. 2007,2009; NGC 7714: Soria & Motch 2004; NGC 4631: Soria & Ghosh 2009). Using X-ray spectral and timing data from the *Chandra* and *XMM-Newton* observatories, I identified thermal and non-thermal emission components. I proposed (Soria & Kuncic 2008; Soria et al. 2009) that a fundamental property of ultraluminous X-ray sources is that they are never dominated by direct thermal emission from the accretion disk (unlike Galactic BHs in a high state). Instead, their X-ray spectra are dominated by a power-law emission component, probably from inverse-Compton scattering of disk photons. I suggested that the inner disk may never be directly visible, even at intermediate and high luminosities, and that the characteristic spectra and time-variability are indicative of a transition between outer thermal disk and inner scattering-dominated region (Soria 2007). I argued that the observational evidence favours BH masses $\lesssim 100 M_\odot$ rather than intermediate-mass BHs (Soria 2007). More generally, I have investigated the issue of **state transitions** between non-thermal and thermal states in accreting BHs (both in Galactic systems with low-mass donor stars, and in ULXs). I constrained the age, donor star and environment of ULXs with studies of their **optical counterparts** (for example, in NGC 4559: Soria et al. 2005; in NGC 1313: Grisé et al. 2008; in ESO 243−49: Soria et al. 2009 submitted). Some ULXs also have a **radio counterpart**, which is interpreted as a signature of current or recent jet activity, and therefore has to be accounted for in the power budget. I estimated the jet contribution by measuring the spectral slope of the radio synchrotron emission and the total energy in the synchrotron lobes or the ionized "ULX bubble" (in NGC 5408: Soria et al. 2006c; NGC 7424: Soria et al. 2006d; NGC 7793: Soria et al. 2010).

I also have a track record in X-ray spectral studies of **AGN** (M 81: Page et al. 2003b,2004; NGC 1365: Risaliti et al. 2008; Guainazzi et al. 2009; NGC 7213: Starling et al. 2005). I constrained the (low) radiative efficiency of nuclear BHs in **X-ray-faint elliptical galaxies**, by comparing their X-ray luminosity with the amount of gas available for accretion, based on optical and X-ray modelling (Soria et al. 2006a,b). This year, I have started to extend such study to the full sample of **nearby spiral galaxies** observed by *Chandra*. The general significance of this work is that we are investigating the gap between low-luminosity AGN and "normal galaxies" with an X-ray detected but faint nuclear BH. We are studying whether there is continuity of physical parameters between the two types of low-state BHs, or instead they have two distinct modes of accretion. We find that the disappearance of the obscuring "torus" can be taken as an indicator of a transition between two distinct classes (Zhang et al. 2009).

Research plan: understanding the most luminous non-nuclear BHs

Different species of black holes

It was a firm belief that astrophysical BHs belong to two classes: (i) non-nuclear, stellar-mass BHs (remnants of stellar evolution), with masses $\sim 10M_{\odot}$, and (ii) nuclear supermassive BHs, with masses $\sim 10^{6}$–$10^{9}M_{\odot}$, with different origin, location and a wide mass gap between them. When accreting gas from their companion stars, stellar-mass BHs are manifested as X-ray binaries; when accreting gas from their environments, supermassive BHs appear as AGN and quasars. This BH dichotomy scenario was shattered by the discovery of extremely luminous non-nuclear X-ray sources (presumably, accreting BHs) in nearby galaxies. The maximum luminosity of an accreting BH is restricted by its mass: the higher the mass, the more luminous the source can be. Some of the newly-discovered sources are 100 times more luminous than allowed for "ordinary" stellar BHs. Hence, some argue that the most extreme sources are powered by BHs of mass $\sim 10^{2}$–$10^{3}M_{\odot}$, perhaps formed from coalescence processes in the cores of massive stellar clusters. On the grander scale of galaxy evolution, cannibal activity occurs throughout the history of the universe: larger galaxies accrete, reap apart and absorb their smaller satellites. If the disrupted dwarf had a nuclear BH, that will end up as a non-nuclear remnant in the larger galaxy. Nuclear IMBHs may be harboured by dwarf galaxies, or by pristine disk galaxies that have just started growing their central BHs. In some cases, remnant BHs tend to sink towards the nuclear regions; but in other cases, a nuclear BH may recoil away from the nucleus during a major merger.

There has also been a rethinking of the phenomenological classification of accretion states. Until a few years ago, stellar-mass BHs were banded according to their X-ray spectral properties, such as low/hard (dominated by Compton scattering in disk coronae), or high/soft (dominated by thermal accretion disk emission) state; and AGN were banded into radio-loud or radio-quiet classes. Now we begin to adopt a more physical approach, based on how the accretion energy is unlocked and transferred to the external environment. It can be advected across the event horizon and lost, or radiated away, or expelled mechanically by jets and winds. Which of these channels dominates at any given time depends on the BH mass and spin, and the conditions of the accreting gas.

In summary, there is compelling evidence of a third class of BHs, whose origins, mass spectrum, accretion properties and environmental impacts are different to those of conventional stellar BHs and supermassive nuclear BHs. To construct a coherent scenario for BH astronomy and to understand the associated astrophysics are my key scientific goals.

Main objectives

A research appointment at the University of Maryland will provide the ideal environment to carry out world-leading research on several aspects of BH accretion/outflows: continuing and extending my current research lines, and tackling new problems, making the most of new ideas and collaboration opportunities. One of the research projects I plan to develop over the next few years is the study of a complete sample of non-nuclear X-ray sources with $L_{\rm X} \approx 10^{40}$–$10^{42}$erg s^{-1}. My objectives are to resolve the nature of these peculiarly luminous X-ray sources, and, eventually, *to establish the BH mass spectrum on scales extending from stars to galaxies.* Specifically, I will (1) quantify their temporal properties, (2) determine their X-ray spectral states and how they are related to their luminosity and accretion rate, and (3) clarify their optical/IR and radio counterparts. In parallel, I will determine the thermal, dynamical and chemical properties of their hosting environments. The possibility that these sources are dwarf nuclear BHs from merged galaxies or super-stellar BHs in star clusters has very important astrophysical implications. They would be the tip of the iceberg of a numerous but mostly undetected remnant population in all galaxies. Observationally, it is of great importance to verify if small spheroidal systems (dwarf galaxies and globulars) also have a (proportionally smaller) nuclear BH, analogous to those in more massive galaxies, perhaps following the same relation between spheroidal mass and nuclear BH mass. Theoretically, it is crucial to verify if there exist alternative effective channels for the production of astrophysical BHs, in addition to stellar collapses, and over what mass range. This project will explore the relation between sub-massive nuclear BHs, super-stellar BHs, and their connections to galaxy assembly on global scales. It will improve our understanding of how BHs are formed, grow and contribute to the energy production of the universe.

Strategies

(1) Source identification: To conduct meaningful population studies, I will search for non-nuclear X-ray sources with luminosities $L_{\rm X}\gtrsim 10^{40}$ erg s^{-1}, in galaxies within ≈ 100 Mpc. I will use the *Chandra*, *Swift*, *XMM-Newton* and (from 2012) *e-ROSITA* databases of pointed observations and large-field surveys. I will consider an X-ray selected sample of galaxies and identify their most luminous non-nuclear sources, determining their luminosity, spectral properties, temporal behaviour, multiband counterparts and spatial locations with respect to the galactic centres and to other galactic features (disk, bulge, halo, tidal tails). For the brightest sources, I will search for relativistic iron X-ray lines. Outflows will be identified via modelling of the soft X-ray line absorption. It has been suggested that ULXs have different accretion state behaviour from usual X-ray binaries. This implies that BH accretion is determined not only by the accretion rate, but also by the boundary conditions of the accretion inflows, and the feeding mechanism. For example: mass transfer from a magnetized/non-magnetized donor star; gas

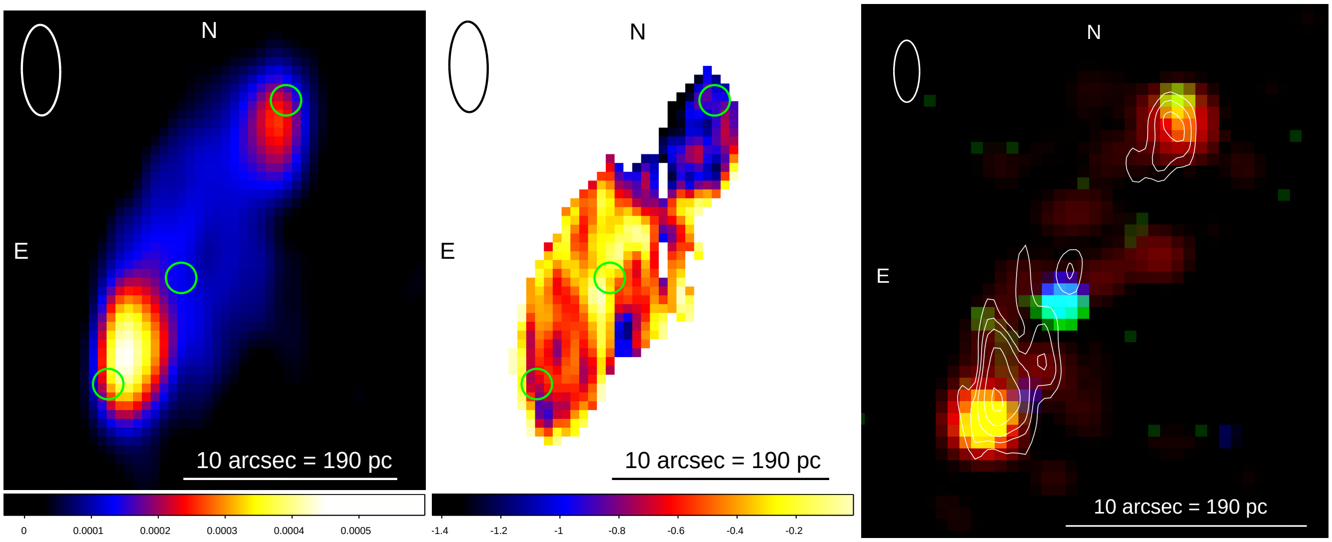

Figure 1: *Left panel*: ATCA 5.5 GHz map of the radio lobes and cocoon around a newly-discovered microquasar in NGC 7793 (Soria et al. 2010, arXiv:0912.2732). The peak flux in the Southern lobe is ≈ 0.45 mJy/beam; for the Northern lobe, ≈ 0.26 mJy/beam. The green circles mark the location of the X-ray core and hot spots, from *Chandra*. *Middle panel*: map of the radio spectral index, inferred from the ratio of the 5.5 GHz and 9 GHz maps, rescaled to the same beam size. Note the two flat-spectrum spurts at the base of the jet. *Right panel*: *Chandra*/ACIS X-ray color map, showing a harder core and softer hot spots, with ATCA 9.0 GHz contours overplotted. The peak radio flux in the Southern lobe is ≈ 0.21 mJy/beam; for the Northern lobe, ≈ 0.11 mJy/beam. I interpret the X-ray hot spots as thermal emission from the shocked interstellar medium just outside the radio-emitting cocoon. With a jet power $\sim$ a few 10^{40} erg s^{-1} and a physical size three times larger than the galactic microquasar SS433, this source is a good test study for BH-driven ISM heating.

inflows triggered by galactic interactions; infall of debris of tidally disrupted stars in a dense star cluster core. An X-ray and multi-frequency monitoring of my sample sources over several years will distinguish the patterns of luminosity variability and spectral transitions in different sub-classes of sources (eg, BHs descending from very massive, metal-poor stellar progenitors versus BHs of non-stellar origin).

(2) Environmental interactions: In accreting BHs, a substantial fraction of the accretion energy may power relativistic jets, which produce synchrotron radiation and Comptonized X-rays; synchtrotron, synchrotron-self-Compton and thermal emission may also come from hot spots and extended radio lobes (eg, the microquasar shown in Fig 1). Combining radio and X-ray studies is a crucial feature of my research. I will constrain the radio/X-ray luminosity ratio and jet power, using archival data and proposing new observations on the VLA, ATCA, GMRT and (in the future) ASKAP and SKA. Optical/radio studies of very large nebulae (~ 50–300 pc) often found around ULXs can effectively probe the integrated mechanical power output. I have already used this technique for the study of several X-ray powered nebulae in nearby galaxies, and I expect to find many more such sources in my extended search. I will examine the host galaxies for clues of recent activities, such as tidal stripping or mergers, which may enable the detection of remnant nuclei of disrupted satellites. Nuclear BHs of normal dwarf galaxies are not easily detectable, as the hosts contain little gas to accrete; but if they are accreted by a larger galaxy, they can be ignited as they cross gas-rich regions. In turn, an accreted satellite can trigger a trail of star formation in its path.

(3) Phenomenological modelling and scenario building: I will revise accretion state models (originally based only on Galactic X-ray binaries and AGN) to accommodate these other classes of BHs. I will constrain their accretion and outflow rates, and estimate how their power is distributed between advection, radiation and mechanical outflows; why some luminous sources are dominated by a thermal accretion disk with no jet, and others by a Comptonizing corona and flaring jet. My main focus will be on sources that are believed to be accreting at or beyond their Eddington limit. The physics of super-Eddington accretion (radiative and mechanical efficiency, effects of winds and radiation trapping) is still poorly known. However, modelling the super-Eddington state is essential for our understanding of how BHs interact with their host environments. In this respect, we may consider super-Eddington ULXs as nearby analogs of distant quasars.

I will use luminosity, timing and spectral measurements to calibrate indirect estimates of BH masses, setting reliable observational constraints to the maximum masses of BHs formed from stellar collapses, and those in star clusters. I will verify my proposed classification of *three species of non-nuclear BHs: (i) systems acquiring most of their mass at birth, from the collapse of a stellar progenitor; (ii) systems built up through coalescence of smaller objects in dense stellar environments; (iii) systems grown by accreting gas from a galactic environment.* BHs in the three classes can have similar masses but very different spin. A higher spin is predicted to enable more powerful jets. I will test this scenario by correlating radio observations with X-ray-derived masses and optical studies of the host environment.