Personal Statement — Roberto Soria

I am committed to good scientific research and sound academic practice. I am also committed to science education, through student teaching and supervision (from undergraduate to doctoral level), and public outreach, such as giving talks at schools and astronomical societies, maintaining web pages and blogs, taking part in recruitment activities and open days. I believe Macquarie University provides a suitable environment to achieve my goals. I have the skills to contribute to the development of a strong research group, making good use of the current strengths of the astronomy programme, and of the AAT facilities, fostering collaborations between different areas of expertise and providing an attractive environment for new talented researchers and students to join in. I will ensure that the AAO maintains its strong research output by providing on-site technical support. I briefly discuss my research directions if I am offered a Lectureship at Macquarie.

Nuclear black holes in spheroidal systems

Massive galaxies (ellipticals and early-type spirals) contain nuclear black holes (BHs) with masses $\sim 10^6$–$10^9 M_\odot$. Scaling relations between the nuclear BH mass and the spheroidal mass and velocity dispersion suggest coevolution of the BH and host galaxy. Larger galaxies are at least partly assembled from smaller units: we do not know whether those units also contain smaller nuclear BHs, and if so, what happens to such BHs after galaxy mergers, and on what timescale they grow. My first goal is to determine what fraction of dwarf galaxies and late-type disk galaxies contain a nuclear BH (perhaps coexisting with a nuclear star cluster). My second goal is to constrain the BH merger rate, which can be verified by future detectors such as the LISA gravity-wave mission.

The AAOmega/SPIRAL integral field unit is a useful instrument for dynamical modelling. I plan to carry out deep spectroscopic studies of a well-defined sample of nucleated dwarf galaxies, to determine the relation between the nuclear cluster and host galaxy. Tidal forces are predicted to deform or disrupt a nuclear star cluster into a disk-like configuration, if there is a nuclear BH. The shape (kurtosis) of the stellar line profiles in the nuclear region will provide an observational test. The AAT study will reveal the most promising candidates for nuclear BHs, which I will further observe with HST, VLT and Gemini at subarcsec resolution.

Accretion flows

Accreting BHs show a variety of phenomenological "spectral states", with recurrent transitions between them. Such transitions correspond to changes in the physical structure of the inflow, in the efficiency of gravitational energy extraction, and in the redistribution of outgoing power between the various radiative and non-radiative channels (accretion disk, corona, jet, winds). It is a matter of intense debate whether/when a jet, a disk and a hot corona can coexist, how the accretion power is partitioned between those components, how much energy may be advected into the BH, and what happens at very high mass-accretion rates, above the limit for disk stability.

Changes in the mass-accretion rate drive state transitions; but an additional driver is also needed to explain the observations satisfactorily. The magnetic field plays a fundamental role to regulate angular momentum transport and accretion: magnetic turbulence transports angular momentum radially outwards, while the torque exerted by a large-scale field transports it vertically outside the disk. This suggests fundamental similarities between disks around BHs and around objects such as protostars. It was proposed that topological rearrangements of the magnetic field may create ordered, large-scale field lines from an initially stochastic field, enabling the launching of a jet and changing the observational appearance of the disk. To test this hypothesis, in collaboration with my Australian colleagues (Prof. Bicknell, Dr. Kuncic), I am developing self-consistent numerical simulations of turbulent, magnetised, radiative plasma. My specific role is to test the theoretical predictions against the X-ray and radio data, and use the latter to develop and refine the models. Prof. Wardle is a leading expert in the modelling of magnetized protostellar disks, and I would relish the opportunity to collaborate with him.

Black hole/interstellar medium interaction

The most luminous non-nuclear accreting BHs (known as ultraluminous X-ray sources) are often surrounded by ionized nebulae, with sizes ~ 100 pc. Three scenarios have been proposed for these nebulae: hypernova remnants; photoionized by the X-ray source; shock-ionized by a BH jet/wind. They may reveal the formation process of the central BH, and be used as a calorimeter to determine the integrated power output of the BH and constrain its mass. The AAOmega/SPIRAL spectrograph (in conjunction with radio and X-ray studies) is a useful tool to map the ionized nebulae, determine the gas kinematics and infer their origin. This research will complement Macquarie's strong expertise in the study of supernova remnants. The science goals for this project are to determine the mass distribution of BHs in the Universe, the upper mass limit from individual stellar collapses, and test the claimed detection of intermediate-mass BHs. Moreover, I study ultraluminous X-ray sources as local-Universe test cases for the feedback effect of BHs accreting above the Eddington limit onto the surrounding gas and stellar environment.

With my experience in multi-band astronomy, I will contribute to the development of new research projects that exploit a combined ground-based (AAT, ATCA) and space-based (*Chandra*, *XMM-Newton*, *Spitzer*, *Herschel*) database. I will continue my international collaborations with Prof. Swartz (NASA-MSFC), Prof. Fabbiano (Harvard CfA), Prof. Zhang (Tsinghua University), and other colleagues at University College London, Strasbourg Observatory, Sydney Uni and the ANU. I will remain involved in multi-band X-ray and infrared studies of starburst/quasar connections through a collaboration with Dr. Page at University College London. I am familiar with the Australian research environment, as I have graduated from the ANU, and I am a regular visiting researcher at Sydney University and the ANU. An appointment at Macquarie would allow me to achieve my science goals.