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The Multi-Messenger Astrophysics of the Galactic Centre

Edited by

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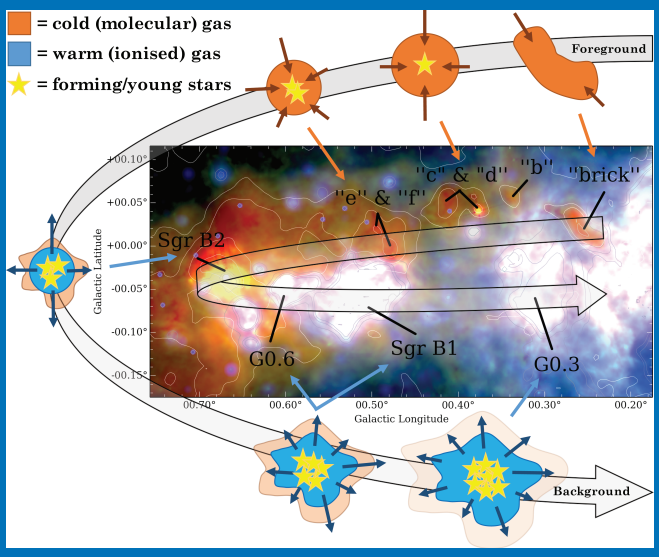

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THE MULTI-MESSENGER ASTROPHYSICS OF THE GALACTIC CENTRE

IAU SYMPOSIUM 322

COVER ILLUSTRATION:

This composite Spitzer and Herschel figure from Barnes et al (this volume) shows the distribution of dense gas and young stars in a $\sim 70 \times 40$ parsec region of the Galactic Centre, which contains several actively star-forming and quiescent gas clouds. The blue and red colour scales indicate warm and cool gas luminosities, respectively. The white and grey contours show the warm and cool gas column densities, respectively. These gas components have been used to determine the total gas masses and the total embedded stellar masses towards each source, which are labeled on the map. The transparent curved arrow represents the path of the orbital model (Kruijssen, Dale & Longmore 2015), with labels of time since pericentre passage according to this model. It has been suggested that strong tidal forces compress the gas clouds at the pericentre of this orbit, causing gravitational collapse and triggering star formation (see Kruijssen, this volume). This figure highlights the increasing stellar masses embedded within the gas clouds (up to around a few percent of the gas mass) and increasing spatial extent of the hot gas component along this orbit, over a timescale comparable to several free-fall times.

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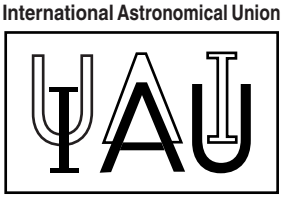

THE MULTI-MESSENGER ASTROPHYSICS OF THE GALACTIC CENTRE

PROCEEDINGS OF THE 322nd SYMPOSIUM OF THE INTERNATIONAL ASTRONOMICAL UNION HELD IN QUEENSLAND, AUSTRALIA JULY 18–22, 2016

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Preface to IAU Symposium 322

The Galactic Centre represents a unique and extreme environment in the Galaxy. Hosting the Galaxy's supermassive black hole, the Milky Way's most concentrated dense gas reservoir and its most extreme star-formation environment, it is the nearest analogue to both an AGN and a starburst system. Definitionally the bottom of the Galaxy's gravitational well, the Galactic Centre should be the region displaying the brightest radiative signature of dark matter decay/annihilation in the Galaxy, albeit against a very bright background due to the region's 'astrophysical' emissions.

IAU Symposium 322, reported on in this volume, builds on the history within the Galactic Centre community of holding regular international meetings (Japan (1997), Chile (1996), USA (1998), USA/Pacific (2002), Germany (2006), China (2009), and USA (2013)). It represents the first time the meeting has come to Australia.

We chose to structure the meeting around 11 themes:

1. New results of interest
2. Approaching the event horizon
3. Dense gas in the Galactic Centre and its star formation potential
4. Young and massive stars in the Galactic Centre
5. Stellar end products in the Galactic Centre; GC star formation history
6. Dark Matter in the GC?
7. X-rays and plasma
8. Galactic Centre Gamma-Rays, Cosmic Rays, Magnetic Fields
9. Positrons
10. Nuclear clusters, cluster dynamics, close orbits; relation to black hole feeding
11. Understanding the GC in relation to other galaxies and in the context of stellar/AGN feedback

Our understanding of the Galactic Centre and the inner Galaxy is in the throes of a revolution driven by advances in instrumentation and theory. Since the last Galactic Centre Meeting (IAU Symposium 303 'The Galactic Center: Feeding and Feedback in a Normal Galactic Nucleus', 2013 September 30 - October 4, Santa Fe, New Mexico), our view of the Galactic Centre has significantly developed with a number of instruments and instrumental collaborations presenting new observations of the region or explaining their progress towards making observations.

Significant new instrumentation and/or data-taking campaigns reported on during IAUS322 included:

• The Event Horizon Telescope (EHT) project that is assembling a high frequency Very Long Baseline Interferometry (VLBI) array that should be able to resolve the SgrA* supermassive black both spatially and temporally. There were a number of EHT talks during the meeting (Blackburn, Falcke, Fish).

• ALMA full operations have commenced allowing us to resolve the dense gas (i.e., not just CO) structure in nearby galaxies for the first time; there is much insight to be derived from comparing this to the recent wide-area surveys of dense gas in our own GC. In addition, in ALMA Cycle 1 and 2, many projects were awarded time to look at individual dense gas clouds in the CMZ in detail (see contributions from Moser et al., Murchikova et al., and Uehara et al.).

• The first systematic interferometric survey of the dense gas in the CMZ is now being conducted with the Harvard-Smithsonian Submillimeter Array ('CMZoom'). This will provide the first sub-pc (0.05pc = star forming core scale) survey of the region, allowing

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the predictions of turbulent star formation theories to be tested (see the contributions from Battersby et al., Walker et al., Liu et al.).

• The Australia Telescope Compact Array is currently conducting "SWAG" — another dense gas and cm-continuum survey of the entire CMZ (see the contribution from project leader Juergen Ott and poster by Krieger et al).

• The Mopra survey of CO emission across the CMZ is well underway (see the contribution from Blackwell).

On the high-energy side, there were also a number of interesting contributions including:

• Despite its tragically premature demise, the Hitomi X-ray satellite operated for long enough to demonstrate the power of very high precision X-ray spectroscopy (see the contribution from Odaka).

• The gamma-ray community is eagerly anticipating the substantially increased resolution and sensitivity of the Cherenkov Telescope Array whose construction has just begun (talk by van Eldik).

From small to large scales around the SMBH, gamma-ray data continue to provide surprises and mysteries; indeed, a strong spectral signal consistent with annihilation of 10 GeV-scale WIMP dark matter particles peaking towards the Galactic Centre continues to draw attention. Yet because this is a crowded and unique environment within the Galaxy, we cannot dismiss the prospect that some hitherto underappreciated process or type of 'conventional' source is ultimately responsible for this and other anomalous signals. One significant priority of the meeting was to facilitate direct discussion between the community of researchers working on Dark Matter interpretations of the Fermi spectral anomaly (amongst other promising signals) and those who work on understanding the 'conventional' astrophysics of the region and much fruitful interaction was indeed forthcoming (see the contribution from Bergstrom)

One exciting achievement, we trust, of the conference was to bring together different communities to start a conversation working towards the goal of a self-consistent understanding of the mass flows and energy cycles through the central regions of the Milky Way and other galaxies, from the kpc-scale mass flows from the disk (Suzuki, Combes, and others), through the star formation and feedback cycles (Kruijssen, Krumholz, Henshaw, Barnes, Federrath, others), to the feeding of and feedback from the central SMBH (many contributions). Such a holistic picture of the feeding and feedback in the inner regions of galaxies is of fundamental importance to many areas of astrophysics, and we hope to see substantial progress in that direction in the next few years — perhaps the focus of the next conference(?).

Finally we note that, while some speakers have chosen not to provide a Proceedings contribution, many slides from the Symposium are available on line at:

http://galacticcentre.space/index.php/programme/

We thank all the participants for a most enjoyable and productive meeting in lovely Palm Cove, Australia.

The editors

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