# Research summary

## 1 Name

Michał J. Michałowski

## 2 Degrees

| | |
|---|---|
| 04.12.2009 | PhD degree, University of Copenhagen; Thesis: "Star Formation at High Redshifts and the Importance of Dust Obscuration" |
| 29.08.2006 | Master degree, University of Copenhagen; Thesis: "Spectral Energy Distributions of Gamma Ray Burst Host Galaxies" |
| 27.06.2006 | Master degree, Adam Mickiewicz University; Thesis: "Analysis of Galaxy Spectra in the Cluster Abell 1677" |

## 3 Employment

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|---|---|
| 05.2017–04.2019 | NCN Polonez Marie Skłodowska-Curie Fellow, Adam Mickiewicz University, Poland |
| 08.2016–04.2017 | Senior postdoctoral fellow, Institute for Astronomy, University of Edinburgh, UK |
| 10.2013–07.2016 | Postdoctoral fellow, Institute for Astronomy, University of Edinburgh, UK |
| 10.2012–09.2013 | FWO Pegasus Marie Curie Fellow, University of Gent, Belgium |
| 01.2010–09.2012 | Postdoctoral fellow, Institute for Astronomy, University of Edinburgh, UK |
| 11–12.2009 | Short-term postdoctoral fellow, Dark Cosmology Centre, University of Copenhagen, Denmark |
| 09–10.2006 | Research assistant, Dark Cosmology Centre, University of Copenhagen, Denmark |

## 4 Habilitation research accomplishment

### 4.1 Title

The interplay of interstellar medium and star formation across the cosmic time

### 4.2 Publication statistics of the habilitation research accomplishment

| | |
|---|---|
| Total number of peer-reviewed papers | 12 |
| Total number of citations | 352 |
| Total impact factor | 59.149 |

## 4.3 Publications

H1 Spring E. F. & **Michałowski M. J.**, 2017, Monthly Notices of the Royal Astronomical Society, Letters, 471, 101, *Observational Evidence For Constant Gas Accretion Rate Since* $z = 5$
Number of citations: 1, impact factor: 4.952

H2 **Michałowski M. J.**, Dunlop J. S, Koprowski M. P., Cirasuolo M., Geach J. E., Bowler R. A. A., Mortlock A., Caputi K. I., Aretxaga I., Arumugam V., Chen Chian-Chou, McLure R., Birkinshaw M., Bourne N., Farrah D., Ibar E., van der Werf P., 2017, Monthly Notices of the Royal Astronomical Society, 469, 492 *The SCUBA-2 Cosmology Legacy Survey: the nature of bright submm galaxies from 2 deg$^2$ of 850-$\mu$m imaging*
Number of citations: 8, impact factor: 4.952

H3 **Michałowski M. J.**,, Castro Cerón J. M., Wardlow J. L., Karska A., Messias H., van der Werf P., Hunt L. K., Baes M., Castro-Tirado A. J., Gentile G., Hjorth J., Le Floc'h E., Pérez Martínez R., Nicuesa Guelbenzu A., Rasmussen J., Rizzo J. R., Rossi A., Sánchez-Portal M., Schady P., Sollerman J., Xu D., 2016, Astronomy & Astrophysics, 595, A72, *GRB 980425 host: [CII], [OI] and CO lines reveal recent enhancement of star formation due to atomic gas inflow*
Number of citations: 5, impact factor: 5.185

H4 **Michałowski M. J.**, Gentile G., Kamphuis P., Hjorth J., Krumholz M. R., Tanvir N. R., Burlon D., Baes M., Basa S., Berta S., Castro Cerón J. M., Crosby D., D'Elia V., Elliott J., Greiner J., Hunt L. K., Klose S., Koprowski M. P., Le Floc'h E., Malesani D., Murphy T., Nicuesa Guelbenzu A., Palazzi E. Rasmussen J., Rossi A., Savaglio S., Schady P., Sollerman J., de Ugarte Postigo A., Watson D., van der Werf P., Vergani S. D., Xu D., 2015, Astronomy & Astrophysics, 582, A78, *Massive stars formed in atomic hydrogen reservoirs: HI observations of gamma-ray burst host galaxies*
Number of citations: 20, impact factor: 5.185

H5 **Michałowski M. J.**, 2015, Astronomy & Astrophysics, 577, A80, *Dust production 680–850 million years after the Big Bang*
Number of citations: 25, impact factor: 5.185

H6 Zavala J. A., **Michałowski M. J.**, Aretxaga I., Wilson G. W., Hughes D. H., Montaña A., Dunlop J. S., Pope A., Sánchez-Arguelles D., Yun M. S., Zeballos M., 2015, Monthly Notices of the Royal Astronomical Society Letters, 453, L88, *Early Science with the Large Millimeter Telescope: Dust constraints in a* $z \sim 9.6$ *galaxy*
Number of citations: 6, impact factor: 4.952

H7 Kohn S., **Michałowski M. J.**, Bourne N., Baes M., Fritz J., Cooray A., de Looze I., De Zotti G., Dannerbauer H., Dunne L., Dye S., Eales S., Furlanetto C., Gonzalez-Nuevo J., Ibar E., Ivison R. J. Maddox S. J., Scott D., Smith D. J. B., Smith M. W. L., Symeonidis M., Valiante E., 2015, Monthly Notices of the Royal Astronomical Society, 448, 1494, *Far-infrared observations of an*

*unbiased sample of gamma-ray burst host galaxies*
Number of citations: 8, impact factor: 4.952

H8 **Michałowski M. J.**, Hayward C. C., Dunlop J. S., Bruce V. A., Cirasuolo M., Cullen F., Hernquist L., 2014, Astronomy & Astrophysics, 571, A75, *Determining the stellar masses of submillimetre galaxies: the critical importance of star formation histories*
Number of citations: 41, impact factor: 4.378

H9 **Michałowski M. J.**, Hunt L. K., Palazzi E., Savaglio S., Gentile G., Rasmussen J., Baes M., Basa S., Bianchi S., Berta S., Burlon D., Castro Cerón J. M., Covino S., Cuby J.-G., D'Elia V., Ferrero P., Götz D., Hjorth J., Koprowski M. P., Le Borgne D., Le Floc'h E., Malesani D., Murphy T., Pian E., Piranomonte S., Rossi A., Sollerman J., Tanvir N. R., de Ugarte Postigo A., Watson D., van der Werf P., Vergani S. D., Xu D., 2014, Astronomy & Astrophysics, 562, A70, *Spatially resolved dust properties of the GRB 980425 host galaxy*
Number of citations: 22, impact factor: 4.378

H10 **Michałowski M. J.**, Dunlop J. S, Ivison R. J., Cirasuolo M., Caputi K. I., Aretxaga I., Arumugam V., Austermann J. E., Chapin E. L., Chapman S. C., Coppin K. E. K., Egami E., Hughes D. H., Ibar E., Mortier A. M. J., Schael A. M., Scott K. S., Smail I., Targett T. A., Wagg J., Wilson G. W., Xu L., Yun M., 2012, Monthly Notices of the Royal Astronomical Society, 426, 1845, *AzTEC half square degree survey of the SHADES fields - II. Identifications, redshifts, and evidence for large-scale structure*
Number of citations: 23, impact factor: 5.521

H11 **Michałowski M. J.**, Dunlop J. S, Cirasuolo M., Hjorth J., Hayward C. C., Watson D., 2012, Astronomy & Astrophysics, 541, A85, *The stellar masses and specific star-formation rates of submillimetre galaxies*
Number of citations: 107, impact factor: 5.084

H12 **Michałowski M. J.**, Murphy E. J., Hjorth J., Watson D., Gall C., Dunlop J. S, 2010, Astronomy & Astrophysics, 522, A15, *Dust grain growth in the interstellar medium of* $5 < z < 6.5$ *quasars*
Number of citations: 71, impact factor: 4.425

## 4.4 Description of the scientific goals and results

The interstellar medium (dust and gas in galaxies) plays an important role in the process of star formation and in galaxy evolution.

Cosmic dust is a key ingredient of the Universe. It absorbs $\sim 50\%$ of starlight and emits this energy in the infrared (Hauser & Dwek, 2001). It also hides regions where stars actually form. Hence, to have a full picture of the Universe, we need to study dusty galaxies to learn about this intriguing hidden half of the Universe.

On the other hand gas is the fuel of star formation, so it is important to understand which gas properties allow and are necessary for gravitational collapse and subsequent formation of stars. One of the most important aspects of the evolution of the Universe is how galaxies acquire the gas that fuels star formation. Numerical galaxy formation models require significant gas inflows from the intergalactic medium (IGM) to fuel star formation (e.g. Schaye et al., 2010), and indeed the current gas reservoirs in many galaxies are too low to sustain the current level of star formation, even for normal galaxies like the Milky Way (e.g. Draine, 2009). However, despite much indirect evidence for gas inflows (e.g. Sancisi et al., 2008; Sánchez Almeida et al., 2013, 2014b,a; Stott et al., 2013; Wang et al., 2015), they have been claimed to be observationally detected in only a handful of galaxies (Ribaudo et al., 2011; Martin et al., 2014; Michałowski et al., 2015; Turner et al., 2015; Rauch et al., 2016), including host galaxies of long (duration $> 2$ s) gamma-ray bursts (GRBs).

### 4.4.1 Goals

In my research I aimed at answering the following questions related to the interplay between the interstellar medium and star formation. They are described in details below.

1. How much gas is being accreted by galaxies and can therefore be used for star formation?
2. (a) How can we select galaxies that have recently experienced gas accretion from the intergalactic medium (in order to study this process in details)?
   (b) Can star formation be fuelled only by molecular gas, or also by atomic gas?
3. (a) What is the mechanism of star formation of the most dusty galaxies in the Universe?
   (b) What are their stellar masses, i.e. cumulative past star formation?
4. What is the mechanism of dust production in the early Universe, when we observe copious amount of dust, but the time available for this process was very short?

### 4.4.2 First observational measurement of the gas accretion rate density

The first issue is to determine how much gas is available for star formation. In Spring & Michałowski (2017, H1), led by a student solely supervised by me, we investigated this by calculating the total amount of gas galaxies accreted at a given epoch of the Universe evolution. We used the method proposed by me based on comparing the total amounts of atomic and molecular gas, as well as stars at two different epochs and ascribing the difference to the effect of gas flowing in and out of galaxies. In this way we obtained the first observational measurement of the gas accretion rate density.

We showed that the gas accretion rate density was approximately constant from $z \sim 5$ to $z \sim 0$ at the level of $\sim 0.05$–$0.1\, M_\odot\, \mathrm{yr}^{-1}\, \mathrm{Mpc}^{-3}$. This has an important consequence for galaxy evolution. The measured decline in star formation rate (SFR) density (a key characteristic of the Universe) cannot be attributed to a change in gas accretion rate. Galaxies in the earlier universe used up their gas supplies faster than the accretion of fresh gas could maintain (SFR density was larger than the gas accretion rate density). SFR density now has dropped beneath the gas accretion rate density, so the current star formation is now sustainable. This drop in SFR density is therefore not due to decrease in gas supply. It could be because average density of gas in galaxies dropped, leaving significant amounts of gas below the star-formation threshold.

We also showed that some cosmological simulations do not predict such constant gas accretion rate density, and we therefore opened an opportunity to study this aspect in other simulations, helping to constrain them.

### 4.4.3 Gamma-ray bursts as tracers of recent gas inflow and resulting star formation

The next question is related to the aspect of the change in the interstellar medium (gas accretion) influencing star formation.

Because GRBs are explosions of very massive and short-lived stars (e.g. Hjorth et al. 2003; Stanek et al. 2003; for a review see Hjorth & Bloom 2012), they pinpoint locations of recent star formation. Star formation is usually assumed to be fuelled by molecular gas (Carilli & Walter, 2013; Rafelski et al., 2016), but several GRB host galaxies show a deficit in molecular gas ($H_2$; Hatsukade et al., 2014; Stanway et al., 2015b; Michałowski et al., 2016). This deficit is unusual for galaxies with normal star formation rates (SFRs) unlike for extreme starbursts, and is not due to a high CO-to-$H_2$ conversion factor (which happens at low metallicity; Bolatto et al., 2013), as CO-targeted GRB hosts have metallicities $12 + \log(O/H) \sim 8.7$–9.0 (Castro-Tirado et al., 2007; Levesque et al., 2010b; Stanway et al., 2015a). Moreover, optical spectroscopy of GRB afterglows implies that the molecular phase constitutes only a small fraction of the gas along the GRB line of sight (Vreeswijk et al., 2004; Fynbo et al., 2006; Tumlinson et al., 2007; Prochaska et al., 2009; D'Elia et al., 2010, 2014; Krühler et al., 2013; Friis et al., 2015).

On the other hand, in Michałowski et al. (2015, H4) I presented the Australia Telescope Compact Array (ATCA) 21 cm line survey of GRB host galaxies showing high levels of atomic hydrogen (H I), suggesting that the connection between atomic gas and star formation is stronger than previously thought. The low levels of $H_2$, normal H I content and high star formation activity suggest that GRB hosts has recently experienced inflow of metal-poor atomic gas. The gas inflow scenario is also supported by the existence of the companion H I object with no optical counterpart $\sim 19$ kpc from the GRB 060505 host, which may be a stream of gas inflowing on this galaxy (Michałowski et al., 2015, H4). In addition the H I centroids of the GRB 980425 and 060505 hosts do not coincide with the optical centres of these galaxies, but are located close to the GRB positions (Michałowski et al., 2015, H4). The concentration of H I close to the GRB 980425 position has been confirmed with high-resolution H I imaging by the Giant Metrewave Radio Telescope (GMRT; Arabsalmani et al., 2015).

Moreover, star formation may be directly fuelled by atomic gas, as has been theoretically shown to be possible (Glover & Clark, 2012; Krumholz, 2012; Hu et al., 2016), and this is supported by the existence of H I-dominated, star-forming regions in other galaxies (Bigiel et al., 2008, 2010; Fumagalli & Gavazzi, 2008; Elmegreen et al., 2016). This can happen in a low metallicity gas that is recently acquired (even if the metallicity in other parts of a galaxy is higher) near the onset of star formation because cooling of gas (necessary for star formation) is faster than the H I-to-$H_2$ conversion (Krumholz, 2012). Indeed, large atomic gas reservoirs, together with low molecular gas masses (Hatsukade et al. 2014; Stanway et al. 2015b, Michałowski et al. (2016, H3)) and stellar masses (Perley et al., 2013, 2015; Vergani et al., 2015), indicate that GRB hosts are preferentially galaxies that have very recently started a star formation episode. This provides a natural route for forming GRBs in low-metallicity environments, as found for most GRB hosts (Fruchter et al., 2006; Modjaz et al., 2008; Levesque et al., 2010a; Han et al., 2010; Boissier et al., 2013; Schulze et al., 2015; Vergani et al., 2015; Japelj et al., 2016; Perley et al., 2016b), except of a few examples of hosts with solar or super-solar metallicities (Prochaska et al., 2009; Levesque et al., 2010b; Krühler et al., 2012; Savaglio et al., 2012; Elliott et al., 2013; Schulze et al., 2014; Hashimoto et al., 2015; Schady et al., 2015; Stanway et al., 2015a).

Summarising the ATCA H I data support a scenario whereby GRBs are preferentially produced when low-metallicity gas accretes onto a galaxy and undergoes rapid cooling and star formation before it either forms $H_2$ or mixes with the higher metallicity gas in the remainder of the galaxy. This scenario provides a natural explanation for the low-metallicity and low-$M_{H_2}$ preferences. In contrast, at later stages of star formation molecular gas is the dominant phase in the interstellar medium, but the metals are well mixed, and gas has been further enriched, so massive stars do not end their lives as GRBs, and such metal- and molecular-rich galaxies do not become GRB hosts.

In the follow-up work in Michałowski et al. (2016, H3) I analysed *Herschel* [C II] and [O I] spectroscopy and APEX CO spectroscopy of a GRB hosts. First, I confirmed its deficiency in molecular gas. Second, the [O I] and H I concentrations and the high radiation field and density close to the GRB position are consistent with the hypothesis of a very recent (at most a few tens of Myr ago) inflow of atomic gas triggering star formation. In this scenario dust has not had time to build up (explaining high line-to-continuum ratios). Such a recent enhancement of star formation activity would indeed manifest itself in high $SFR_{line}/SFR_{continuum}$ ratios because the line indicators are sensitive only to recent ($\lesssim 10\,Myr$) activity, whereas the continuum indicators measure the SFR averaged over much longer periods ($\sim 100\,Myr$). Within a sample of 32 other GRB hosts, 20 exhibit $SFR_{line}/SFR_{continuum} > 1$ with a mean ratio of $1.74 \pm 0.32$. This is consistent with a very recent enhancement of star formation that is common among GRB hosts, so galaxies that have recently experienced inflow of gas may preferentially host stars exploding as GRBs. Therefore GRBs may be used to select a unique sample of galaxies that is suitable for the investigation of recent gas accretion.

Moreover, in Michałowski et al. (2014b, H9), the only spatially-resolved study of gas properties of a GRB host galaxy, I showed that the star-forming region close to the GRB position has enhanced far-infrared and radio emission. These properties are consistent with very high density in this region, which are likely a result of recent inflow of gas towards that part of the galaxy.

Finally, in Kohn et al. (2015, H7), led by a student solely supervised by me, we investigated whether GRB hosts can be considered representative star-forming galaxies. This is important in order to use GRBs as a tool to study star formation in the Universe, i.e. to transform the measured GRB rate as a function of redshift into the cosmic star formation rate density. If this can be done, then this will significantly advance our knowledge of the Universe, because this method is not biased against faint undetectable galaxies. This is because the measured quantity is the number of GRBs, which are sufficiently bright to detect, even if their host galaxies are faint. In this work I proposed a method of analysing an unbiased sample of GRB hosts based only on their position within the fields observed by *Herschel*. Based on these far-infrared data we showed that indeed GRB hosts are consistent with the general population of star-forming galaxies.

### 4.4.4 Submm galaxies constraining the galaxy evolution models

The third aspect is what are the star formation properties (reflecting both the current and past star formation) of galaxies with the richest (i.e. most dusty) interstellar medium.

Submm galaxies are the most dusty and most massive galaxies in the Universe, so they can be used to constrain cosmological models (e.g. Hayward et al., 2013). This is because their numbers and physical properties are very sensitive to certain parameters in these models.

In Michałowski et al. (2012b, H10) I analysed a sample of submm galaxies from two fields showing that they likely trace large-scale structure, which opens the possibility to use them to study distribution of matter in the Universe. Moreover, the significant difference between the fields implies the need of larger (>degree squared) fields in order to obtain representative samples of these galaxies. I also designed a method of selecting optical counterparts of submm galaxies based on red colours. This was further improved and applied to the SCUBA-2 Cosmology Legacy Survey in Chen et al. (2016).

In Michałowski et al. (2012a, H11) I, for the first time, proved that most of submm galaxies are not outlying galaxies in terms of star-formation properties, i.e. that they are not outliers on the star formation rate/stellar mass diagram, and that they form the high-mass end of the "main sequence" on this diagram. This challenges the previously assumed picture that submm galaxies are untypical and rare mergers. This distinction is important in order to properly use them to compare with cosmological models.

Michałowski et al. (2012a, H11) and Michałowski et al. (2014a, H8) are the only existing so far tests of the reliability of stellar mass estimations of submm galaxies. I provided to observers the recommendations which star formation history should be used in the spectral energy distribution. Likely the assumption of a double star formation history (with two independent components) is the most appropriate. To have correct stellar mass estimations of submm galaxies is important for both understanding their nature (for example the location on the "main sequence" diagram depends on stellar mass), and an important aspect of using them to constrain cosmological models.

I Michałowski et al. (2017, H2) I reported the physical properties of the largest sample of submm galaxies ($\sim 2\,000$) detected in the $\sim 2\,\mathrm{deg}^2$ survey. This is the first time when the cosmic variance (anisotropy of the Universe when looking at too small scales) has been overcome. I confirmed that submm galaxies form the high-mass end of the "main sequence" and that a significant fraction of massive galaxies at high-z are in fact submm galaxies. I proved this by the comparison of the submm galaxy population with the evolving stellar mass function, taking into account the scatter and measurement errors.

Finally, in Zavala et al. (2015, H6) we addressed a tantalising possibility of dust detection in a $z \sim 9.6$ galaxy reported by Dwek et al. (2014) based on a low-resolution 2 mm detection. We have obtained observing time at the Large Millimeter Telescope with improved resolution, showing that the dusty galaxy is in fact a $z \sim 1$ galaxy, ruling out its great importance. From the deep upper limit at the position of the $z \sim 9.6$ galaxy we concluded that this galaxy is not heavily dust obscured.

#### 4.4.5 How can dust be formed in the distant Universe

Finally, I investigated the opposite problem, namely how star formation (i.e. young stars) influences the interstellar medium. Specifically, I tested whether stellar sources are efficient and numerous enough to explain dust we observe in the early Universe.

It is not obvious yet how the dust in the distant universe was formed, as dust formation requires specific conditions of relatively low temperature and high density. These conditions are met in atmospheres of asymptotic giant branch (AGB) stars and expelled shells of supernova (SN) remnants (see Gall et al. 2011, for a review). Another possibility is that these stellar sources produce only dust seeds, and most dust mass accumulation happens in the interstellar medium (ISM; Draine & Salpeter, 1979).

I designed and applied the method to address this issue. Based on stellar masses of distant galaxies I estimated the number of dust-producing stars (AGB stars and SN), then I divided the measured dust masses of these galaxies by these numbers to obtain the dust yield per star required to explain these dust masses. Then I compared these yields with theoretical and observed stellar dust yields. If the required yields are larger than the theoretical and observed ones, then the conclusion is that given dust producers are not efficient and numerous enough to explain dust in distant galaxies.

In Michałowski et al. (2010b, H12) I analysed quasars at $5 < z < 6.5$ for which dust has been detected. Quasar emission dominates in the optical and near-infrared over the stellar emission, so measuring stellar masses of quasars hosts is more difficult than of other galaxies. Hence, I measured stellar masses based on dynamical (total) and gas masses from CO observations. I obtained very high required dust yields and concluded that AGB stars are not efficient enough to form dust in the majority of the quasars, whereas supernovae may be able to account for dust in some quasars. However, they require very high dust yields (close to maximum). This suggests additional non-stellar dust formation mechanism e.g. significant dust grain growth in the interstellar medium.

In Michałowski (2015, H5), a single-author paper, I applied this method to the most distant galaxies ($z = 6.3$–$7.5$) for which dust emission has been detected: HFLS3, a red *Herschel*-selected $z = 6.34$ galaxy (Riechers et al., 2013); ULAS J1120+0641, a colour-selected $z = 7.085$ quasar (Mortlock et al., 2011; Venemans et al., 2012); and A1689-zD1, a lensed $z = 7.5$ Lyman break galaxy (Watson et al., 2015). Similarly, I found very high required yields, implying that AGB stars could not contribute substantially to dust production at these redshifts, and that SNe could explain these dust masses, but only if they do not destroy most of the dust they form (which is unlikely given the upper limits on the SN dust yields derived for galaxies where dust is not detected). This suggests that the grain growth in the interstellar medium is likely required at these early epochs.

### 4.4.6 Summary

In summary I obtained the following main results. I provided the first measurement of the gas accretion rate density finding out that it is constant, so lower gas supply cannot explain the dramatic decline in the star formation rate density since $z \sim 1.5$ til $z \sim 0$. This opens ways to investigate other mechanisms of this decline, for example changing gas density.

I proposed efficient selection of galaxies which have received a recent gas inflow from the intergalactic medium (GRB hosts). They can therefore be used to study this key process in details. Moreover, I obtained the first observational indications that in some conditions star formation may be fuelled by atomic gas, not the molecular gas. This new mode of star formation was indeed predicted by theoretical studies.

I provided robust evidence that submm galaxies form the massive end of the main-sequence of star-forming galaxies. This enabled me to shed light on their nature, because, as main-sequence galaxies, they are unlikely powered by a violent process like major merger, which would move them above the sequence. This enables using submm galaxies to constrain parameters of cosmological models. Moreover I provided practical recommendations on how to measure the masses of submm galaxies, important for both observers and simulators.

Finally, I found that dust in the very early Universe could not have been produced by AGB stars. SN could explain the detected dust masses, but only if they are maximally effective, which is unlikely. Hence, I concluded that a non-stellar mechanism is responsible for the bulk of the dust mass accumulation in the early Universe, for example grain growth in the interstellar medium. This is important because this first dust was a catalyst for formation of molecular gas and therefore helped further star formation.

# 5 Other research activities

## 5.1 Other lines of research

I have started my independent research career already during my PhD studies when I designed independent projects on submm galaxies, as there was no submm expertise in Copenhagen (Michałowski et al., 2010a,c, 172 and 110 citations). Since then I have led two large radio observational programs managing the team of co-authors for data reduction and analysis (Michałowski et al., 2012c, 2015); and an interdisciplinary (observations+simulations) project characterising the limitations of the derived stellar masses of submm galaxies (Michałowski et al., 2012a, 2014a) I am now leading radio and submm campaigns for GRB hosts and passive galaxies, with my accepted PI proposals. Three of my undergraduate student (for whom I was the sole supervisor) wrote first-author papers on the project I supervised (Kohn et al., 2015; Spring & Michałowski, 2017, Okalidis, Michalowski, in prep.). My PhD student (co-supervised with J. Dunlop) published two papers (Koprowski et al., 2014, 2016). A PhD student at the INAOE Mexico published a paper based on my idea and the observing proposal I have written (Zavala et al., 2015). I have obtained the Carnegie Trust Research Incentive Grant and hired postdocs. I will hire additional postdoc this year through my NCN Polonez Marie Skłodowski-Curie grant.

I investigate several other subjects, which do not fit into the scheme of this habilitation research accomplishment. I analysed the radio properties of gamma-ray burst (GRB) host galaxies finding that they are consistent with the general population of star-forming galaxies (Michałowski et al., 2012c; Greiner et al., 2016). This indicates that GRBs can be used as a tool to study cosmic star formation.

I also had significant contribution to the work on short GRBs (believed to be mergers of black holes or neutron stars). In Nicuesa Guelbenzu et al. (2014) and Nicuesa Guelbenzu et al. (2015) we reported highly star-forming host galaxies of short GRBs. This suggests that a fraction of all short-burst progenitors hosted in star-forming galaxies could be physically related to recent star formation activity, implying a relatively short merger timescale.

I am also a member of the H-ATLAS collaboration within which I contributed to around 40 papers, including Negrello et al. (2010) published in *Science* and having attracted more than 200 citations. Our main goals are to comprehensively study dust in local galaxies, as well as to enable the first selection of a significant sample of rare extremely dusty galaxies in the distant Universe, most of which are lensed.

As a member of the SCUBA-2 Cosmology Legacy Survey I led the paper listed above and contributed to approximately 20 others. We have gained the understanding of the most star-forming galaxies in the Universe, including active galaxy nuclei.

I am very active in the investigation of GRBs and their hosts. I played a key role in the first far-infrared *Herschel* survey of GRB hosts, modelling their spectral energy distribution (Hunt et al., 2014). Moreover, I am a member of the unbiased surveys TOUGH (Hjorth et al., 2012) and SHOALS (Perley et al., 2016a,b).

I am also involved in many studies on cosmic dust. This includes the first blank field ALMA survey (Dunlop et al., 2017, attracting over 50 citations). I was responsible for all technical details of this survey and for analysis of the far-infrared emission. With the spectral energy distribution modelling I also contributed to the confirmation of dust emission at $z \sim 7.5$ published in *Nature* (Watson et al., 2015, attracting over 80 citations).

## 5.2 Publication statistics

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| Total number of peer-reviewed papers | 143 | (132 after PhD) |
| Total number of citations (16.08.2017, ADS) | 4396 | |
| H-index | 40 | |
| Total impact factor | 827.55 | |
| Number of first-author papers | 15 | (11 after PhD) |
| Number of citations for the first-author papers | 801 | |
| H-index (the first-author papers only) | 12 | |
| Total impact factor | 85.113 | |

# References

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