Cartan subalgebras and the associated dynamical systems

A Data Management Plan created using DMPonline.be

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Project abstract:

Physical scientists use dynamical systems to model the ever-changing world we live in. Such systems are often complex, so mathematicians encode them in terms that are better understood: by representing them as collections of rigid transformations of infinite-dimensional spaces, called operator algebras, we can analyse the systems using functional analytic tools. My research deals with operator algebras known as C*-algebras.

Operator algebras were first introduced by polymath John von Neumann who discovered that they are the mathematical language of quantum mechanics. Take Heisenberg's uncertainty principle: the more accurately we measure the position of a particle, the less accurately we can measure its momentum. Mathematically, this is because the operators that measure these two observables do not commute: $AB \neq BA$. C*-algebras are built to model such behaviour: their elements likewise do not need to commute.

Since their origins in the 1930s, many techniques have been developed to study the structural properties of C*-algebras, allowing us to derive new information about the quantum systems they encode. Most amenable to those techniques are C*-algebras built from dynamical systems and, by Renault's remarkable theorem, these are exactly the algebras that contain a so-called Cartan subalgebra.

This project will deliver Cartan subalgebras in broad classes of C*-algebras, describe the dynamics in terms of the original data, and determine their geometric properties.

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1. Research Data Summary

List and describe all datasets or research materials that you plan to generate/collect or reuse during your research project. For each dataset or data type (observational, experimental etc.), provide a short name & description (sufficient for yourself to know what data it is about), indicate whether the data are newly generated/collected or reused, digital or physical, also indicate the type of the data (the kind of content), its technical format (file extension), and an estimate of the upper limit of the volume of the data.

				Only for digital data	Only for digital data	Only for digital data	Only for physical data
Dataset Name	**Description**	**New or reused**	**Digital or Physical**	**Digital Data Type**	**Digital Data format**	**Digital data volume (MB/GB/TB)**	**Physical volume**
Notes	The notes I will be writing during meetings and during the production of the final manuscripts.	Generate new data	both digital and physical	Other	.tex, .bib, .docx	<1GB	Some sheets of paper.
Manuscripts	Once "Notes" have been polished for publication, they become a manuscript that contains my research findings.	Generate new data	Digital	Other	.tex, .bib., .docx	<1GB	NA

This research project is in pure mathematics. No datasets will be generated, collected or reused, neither will simulations, models or software be created or used.

If you reuse existing data, please specify the source, preferably by using a persistent identifier (e.g. DOI, Handle, URL etc.) per dataset or data type:

No data will be reused.

Are there any ethical issues concerning the creation and/or use of the data (e.g. experiments on humans or animals, dual use)? Describe these issues in the comment section. Please refer to specific datasets or data types when appropriate.

- No

Will you process personal data? If so, briefly describe the kind of personal data you will use in the comment section. Please refer to specific datasets or data types when appropriate.

- No

Does your work have potential for commercial valorization (e.g. tech transfer, for example spin-offs, commercial exploitation, …)? If so, please comment per dataset or data type where appropriate.

- No

My research does not have potential for commercial valorization.

Do existing 3rd party agreements restrict exploitation or dissemination of the data you (re)use (e.g. Material/Data transfer agreements/ research collaboration agreements)? If so, please explain in the comment section to what data they relate and what restrictions are in place.

- No

Are there any other legal issues, such as intellectual property rights and ownership, to be managed related to the data you (re)use? If so, please explain in the comment section to what data they relate and which restrictions will be asserted.

- No

2. Documentation and Metadata

Clearly describe what approach will be followed to capture the accompanying information necessary to keep data understandable and usable, for yourself and others, now and in the future (e.g., in terms of documentation levels and types required, procedures used, Electronic Lab Notebooks, README.txt files, Codebook.tsv etc. where this information is recorded).

While in use, each instance of the dataset "Notes" will be labelled with the current date and topic, so that it is kept understandable for myself while I produce manuscripts from it. Beyond that time frame and beyond myself, there is no need for the dataset "Notes" to be kept understandable and usable, as it loses its relevance once I have written a corresponding manuscript.
The dataset "Manuscripts" consists of self-contained and self-explained, written published works. As such, it does not require further documentation.

Will a metadata standard be used to make it easier to find and reuse the data? If so, please specify (where appropriate per dataset or data type) which metadata standard will be used. If not, please specify (where appropriate per dataset or data type) which metadata will be created to make the data easier to find and reuse.

- Yes

No metadata will be used for the dataset "Notes".
Each instance of the dataset "Manuscripts" will contain both a list of keywords and the relevant codes of the "2020 Mathematics Subject Classification" (MSC2020) to make the data easier to find and reuse.

3. Data storage & back-up during the research project

Where will the data be stored?

The data "Notes" will be stored as follows:

- Physical notes are stored in the desk drawer of my office in the KU Leuven Mathematics department.
- Digital notes are stored in the cloud editor *overleaf.com*.

"Notes" transition into "Manuscripts" by being uploaded to *arXiv.org*, an open-access archive for mathematical work, where the manuscript remains freely accessible indefinitely. They will further be deposited in Lirias, in accordance with the FWO requirements, and submitted to journals for publication.

How will the data be backed up?

"Notes" do not need to be backed up, as their relevance is very short lived and as they are reproduceable.
Virtual copies of "Manuscripts" will be kept on a local hard drive and in the cloud (*overleaf.com*; personal *DropBox* via automatic sync with overleaf; *OneDrive* through KU Leuven).

Is there currently sufficient storage & backup capacity during the project? If yes, specify concisely.
If no or insufficient storage or backup capacities are available, then explain how this will be taken care of.

- Yes

The datasets I will be generating is of very small digital and physical size (<10 GB respectively one drawer full of notes at any given point in time). The *OneDrive* account through KU Leuven allows for 2 TB of files; maximum size of projects on *overleaf.com* are "unlimited" (see https://www.overleaf.com/learn/how-to/Overleaf_plan_limits).

How will you ensure that the data are securely stored and not accessed or modified by unauthorized persons?

All digital data is stored in online accounts (on *overleaf.com*, *DropBox.com*, *OneDrive* through KU Leuven, *Lirias*, *arXiv.org*) and on devices (laptop provided by SET-IT; personal mobile phone) that are password protected.
All physical data is stored in my locked office in KU Leuven's Mathematics department.

What are the expected costs for data storage and backup during the research project? How will these costs be covered?

There will be no costs associated to data storage and backup.

4. Data preservation after the end of the research project

Which data will be retained for at least five years (or longer, in agreement with other retention policies that are applicable) after the end of the project? In case some data cannot be preserved, clearly state the reasons for this (e.g. legal or contractual restrictions, storage/budget issues, institutional policies...).

"Notes" will have lost their value after five years and will therefore not needed to be retained.
"Manuscripts" will be retained on *arXiv.org*, Lirias, and at the publishing journals indefinitely, i.e., beyond five years after the project has ended.

Where will these data be archived (stored and curated for the long-term)?

"Notes" will not be archived.
"Manuscripts" will be retained on *arXiv.org*, *Lirias*, and at the publishing journals indefinitely.

What are the expected costs for data preservation during the expected retention period? How will these costs be covered?

There are no expected costs.

5. Data sharing and reuse

Will the data (or part of the data) be made available for reuse after/during the project? In the comment section please explain per dataset or data type which data will be made available.

- No (closed access)
- Yes, in an Open Access repository

"No (closed access)": The dataset "Notes" is only for my personal use during the production of manuscripts.
"Yes, in an Open Access repository": All of the dataset "Manuscripts" will be made available on the open-access pre-print server *arXiv.org* and, after an variable embargo period, on *Lirias* and at the publishing journal.

If access is restricted, please specify who will be able to access the data and under what conditions.

The data "Notes" will never be made available to the public, as it is for my own use.
The access of the data that is not for my personal use (i.e., of "Manuscripts") will not be restricted.

Are there any factors that restrict or prevent the sharing of (some of) the data (e.g. as defined in an agreement with a 3rd party, legal restrictions)? Please explain in the comment section per dataset or data type where appropriate.

- No

Where will the data be made available? If already known, please provide a repository per dataset or data type.

The data "Notes" will never be made available to the public.
The data "Manuscript" will be made available on *arXiv.org*, *Lirias*, and at the publishing journals.

When will the data be made available?

The data "Notes" will never be made available to the public.
"Manuscripts" are, by definition, notes that have been uploaded to *arXiv.org* and are therefore immediately and indefinitely available to the public.

Which data usage licenses are you going to provide? If none, please explain why.

Does not apply to "Notes".
"Manuscripts" on *arxiv.org* are either under "CC BY 4.0" or under "arXiv.org perpetual, non-exclusive license to distribute this article (Minimal rights required by arXiv.org) ".

Do you intend to add a PID/DOI/accession number to your dataset(s)? If already available, you have the option to provide it in the comment section.

- No

What are the expected costs for data sharing? How will these costs be covered?

There are no expected costs.

6. Responsibilities

Who will manage data documentation and metadata during the research project?

Anna Duwenig, to the extent it is applicable

Who will manage data storage and backup during the research project?

Anna Duwenig, to the extent it is applicable

Who will manage data preservation and sharing?

Anna Duwenig, to the extent it is applicable

Who will update and implement this DMP?

Anna Duwenig, to the extent it is applicable