

$P_\infty F$

Workshop on Functor Calculus

22–26 June 2015

Münster

\vdots
 $P_n F$

$P_{n-1} F$

\vdots
 $P_1 F$

$P_0 F$

F

Organisers:

Christopher Braun
Federico Cantero
Rosona Eldred
Geoffroy Horel
Martin Palmer

sites.google.com/site/2015muenstercalculus



Unterstützt von / Supported by



Alexander von Humboldt
Stiftung / Foundation



Schedule and abstracts

1	Schedule	4
2	Abstracts	5
2.1	Mini-courses	
2.2	Additional talks	

1. Schedule

	Monday	Tuesday	Wednesday	Thursday	Friday
8:45	Registration				
9:00	M. Ching	G. Arone	T. Pirashvili	P. Lambrechts	O. Röndigs
10:30					
11:00	T. Pirashvili	P. Lambrechts	G. Arone	G. Arone	V. Turchin
12:30	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH
14:30	P. Lambrechts	T. Pirashvili	<i>Excursions</i>	N. Wahl	M. Weiss
16:00	  +discussion Barbecue (19:00)	  +discussion		  +discussion Dinner (18:30)	

All talks will be 1.5 hours, including time for questions. The discussion sessions are intended to be informal, as an opportunity to consolidate the lectures.

Rooms (see also the [ground plan](#)):

- Registration and coffee will be in the **foyer of Orléans-Ring 12**.
Exception: Thursday afternoon's coffee will be in **room 17** of Orléans-Ring 12.
- All talks will take place in room **M6** of the **Hörsaalgebäude**.
- Afternoon discussion sessions will be held in **room 19** of Orléans-Ring 12.

Cake schedule  :

- Monday: Aprikosenkuchen (apricot cake)
- Tuesday: Kirschstreuselkuchen (cherry crumble cake)
- Thursday: Donauwelle (\approx sour cherry marble cake)



2. Abstracts

2.1 Mini-courses

Greg Arone (University of Virginia)

A short course on homotopy calculus.

More specifically, on the operad module structure possessed by the derivatives of a functor, the chain rule, and the classification of polynomial functors. In a little more detail:

- **Talk 1 (Tuesday):** Operad and module structures on derivatives of functors. The role of Koszul duality. The chain rule.
- **Talk 2 (Wednesday):** Further structure on the derivatives of functors. Classification of polynomial functors between Spaces and Spectra.
- **Talk 3 (Thursday):** An informal talk about possible connections with orthogonal calculus on one hand and algebraic calculus on the other hand.

Pascal Lambrechts (Université catholique de Louvain)

A short course on the manifold calculus.

Teimuraz Pirashvili (University of Leicester)

A basic course on polynomial functors and MacLane cohomology and THH.

This includes work with several coauthors (Waldhausen, Jibladze, Franjou etc.) as well as the work of Birgit Richter and Johnson and McCarthy.

2.2 Additional talks

Michael Ching (Amherst College)

An introduction to the calculus of functors.

This talk will be an introduction to some of the basic ideas of the calculus of functors. I will start by examining the notion of a linear functor in a variety of algebraic and topological contexts. Turning to higher degree functors, I will discuss the use of the cross-effect construction to measure the failure of a functor to be of a particular degree. I will then describe the Taylor tower and introduce the derivatives (or Taylor coefficients) of a homotopy functor. While focusing to some

extent on Goodwillie's homotopy calculus, my overall goal will be to illustrate some of the common threads that connect the different varieties of the calculus of functors.

Oliver Röndigs (University of Osnabrück)

Goodwillie calculus and topological realization at odd primes.

In joint work with S. Büscher, F. Hebestreit, and M. Stelzer, we employ the Goodwillie spectral sequence for the iterated loop space functor in order to provide realizability conditions on certain unstable modules over the Steenrod algebra at an odd prime. This follows N. Kuhn's approach for the prime 2.

Victor Turchin (Kansas State University)

Relative deformation theory of the little discs operads and spaces of long embeddings.

I will explain the connection between the Goodwillie-Weiss embedding calculus and the deformation theory of the operads of singular chains of little discs. My talk will deal with the following objects, that I will try to explain in detail:

- Deformation complex of a morphism of differential graded operads
- Operads E_n
- Formality and relative (non-)formality of little discs operads
- Infinitesimal bimodules
- Graph-complexes

Nathalie Wahl (University of Copenhagen)

Homological stability with twisted coefficients.

I will present joint work with Oscar Randal-Williams in which we show that all the classical examples of families of groups satisfying homological stability (including symmetric groups, braid groups, general linear groups, mapping class groups, automorphisms of free groups) also satisfy homological stability with both "polynomial" and "abelian" coefficients. The coefficient systems are defined as functors from an appropriate category associated to the groups and the polynomiality condition is closely related to classical polynomiality in functor homology.

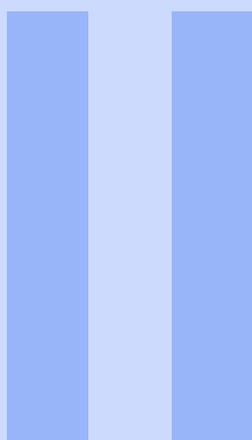
Michael Weiss (University of Münster)

Manifold calculus, configuration categories and Pontryagin classes.

Let $\text{TOP}(m)$ be the homeomorphism group of m -dimensional Euclidean space, viewed as a topological or simplicial group. Let TOP be the union (direct limit) of the $\text{TOP}(m)$. It is known that the inclusion of BO in $B\text{TOP}$ induces an isomorphism in rational cohomology so that the rational cohomology of $B\text{TOP}$ is a polynomial algebra on classes which we can call the *rational Pontryagin classes*, one in degree $4j$ for $j = 1, 2, 3, \dots$. By restricting these Pontryagin classes to $B\text{TOP}(m)$ one obtains classes in the rational cohomology of $B\text{TOP}(m)$.

Question: do they satisfy the relations that we expect when we look in the cohomology of $BO(m)$? Specifically, in the rational cohomology of $BO(2n)$, the Pontryagin classes in degrees greater than $4n$ are zero. That is roughly what I mean by "relations". It turns out that in the cohomology of $B\text{TOP}(2n)$ this does not hold ... although for many years I advertised an elaborate program to show that it holds.

The current status is: the Pontryagin classes in $B\text{TOP}(2n)$ can be nonzero in degrees up to $9n$ minus constant. The proof is a combination of parameterized surgery (following Galatius-Randal-Williams, but used as a black box) and manifold calculus. Manifold calculus (applied to spaces of smooth embeddings) comes in because there are situations where a good knowledge of embeddings can be used to construct useful homeomorphisms. Homeomorphisms act on tangent bundles, which are classified by maps to $B\text{TOP}(m)$ for some m , etc.



Practical information

3	Basic information	8
3.1	Useful numbers	
3.2	Public transport	
3.3	Wifi	
4	Maps	9
4.1	Train station and hotels	
4.2	Hotels and mathematics institute	
4.3	Mathematics institute and lunch	
4.4	Ground plan of the mathematics buildings	
4.5	Barbecue	
4.6	Workshop dinner	
4.7	Recommended restaurants, etc.	
5	Excursions and bike hire	14
5.1	Wednesday afternoon	
5.2	Bike hire	



3. Basic information

3.1 Useful numbers

- Ambulance, police or fire service: **112**.
- Hotel am Schlosspark: (+49 or 0) 251 899 8200
- Hotel Überwasserhof: (+49 or 0) 251 41770

3.2 Public transport

Timetable information for local buses can be found here:

stadtwerke-muenster.de/privatkunden/busverkehr/fahrplanauskunft/efa/fahrplanauskunft.html.

The hotels are 20 or 30 minutes' walk (for Überwasserhof and Schlosspark respectively) from the train station. See also the [Maps](#) section. Alternatively, here are some buses to look out for:

- From the station to Hotel Überwasserhof:
(daytime) StadtBus 5 or 6
(after approx. 9pm) N85 or E85, which run roughly every half hour
- From the station to Hotel am Schlosspark:
(daytime) StadtBus 1, 5 or 6
(after approx. 9pm) N85, E85 or R73

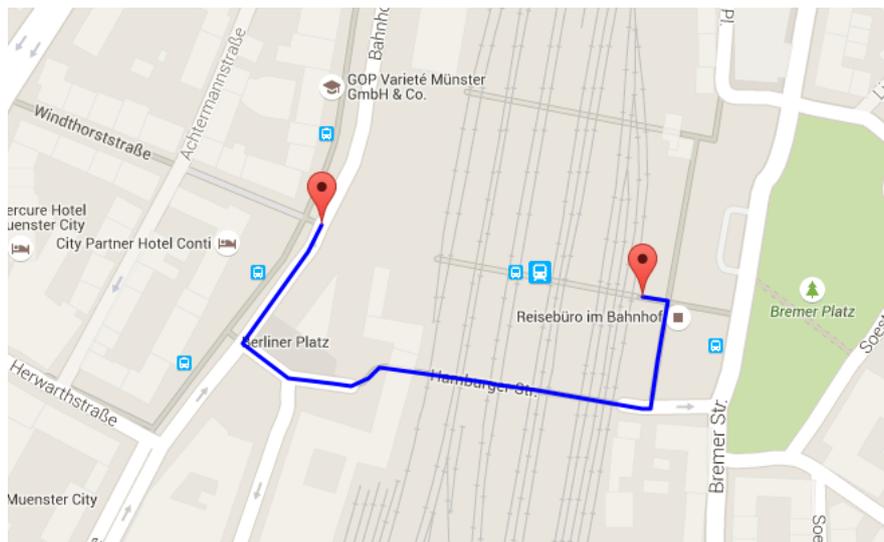
3.3 Wifi

- **Eduroam** is available in all university buildings in Münster, including all areas where talks/coffee will take place.
- If you do not have an eduroam account, you can pick up a registration form for a **wifi account** from the welcome desk or during any of the coffee breaks. You will then have your own username and password for an account which will be available until 29th June.

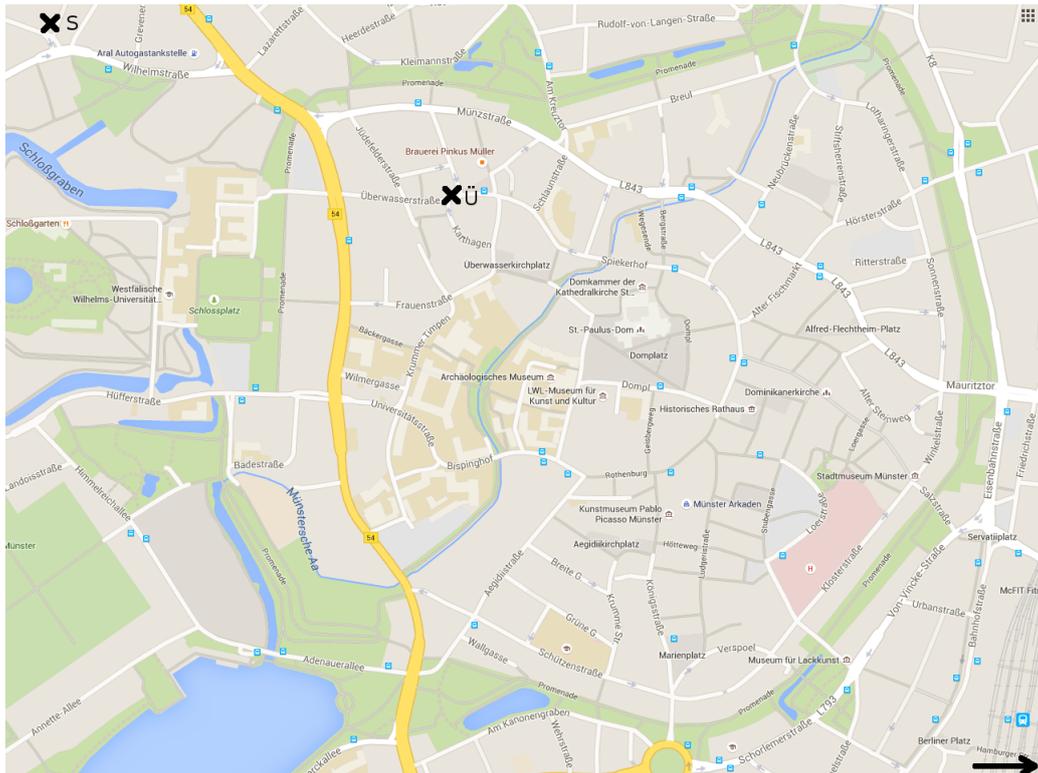
4. Maps

4.1 Train station and hotels

The train station is currently under construction, so you will have to exit through the back entrance and then be redirected through a tunnel to the front (i.e. the side facing the city centre). From here the walk to Hotel Überwasserhof is about 20 minutes, and to Hotel am Schlosspark is about 30 minutes. Alternatively, you can take the bus from in front of the station – local bus timetables can be found here: stadtwerke-muenster.de/privatkunden/busverkehr/fahrplanauskunft/efa/fahrplanauskunft.html.



Redirection around the train station.

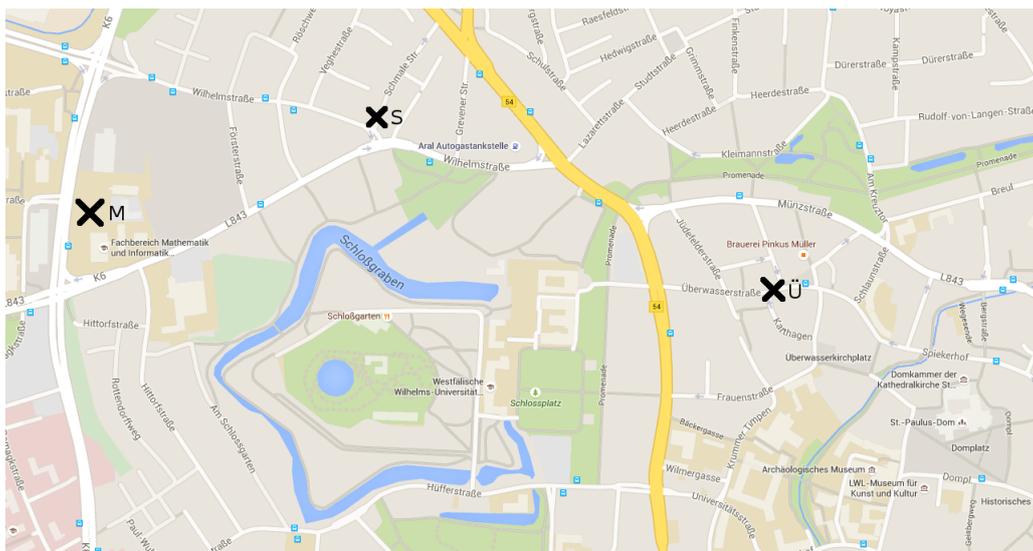


The train station is at the bottom-right; S = Hotel am Schlosspark, Ü = Hotel Überwasserhof.

4.2 Hotels and mathematics institute

The hotels' addresses are:

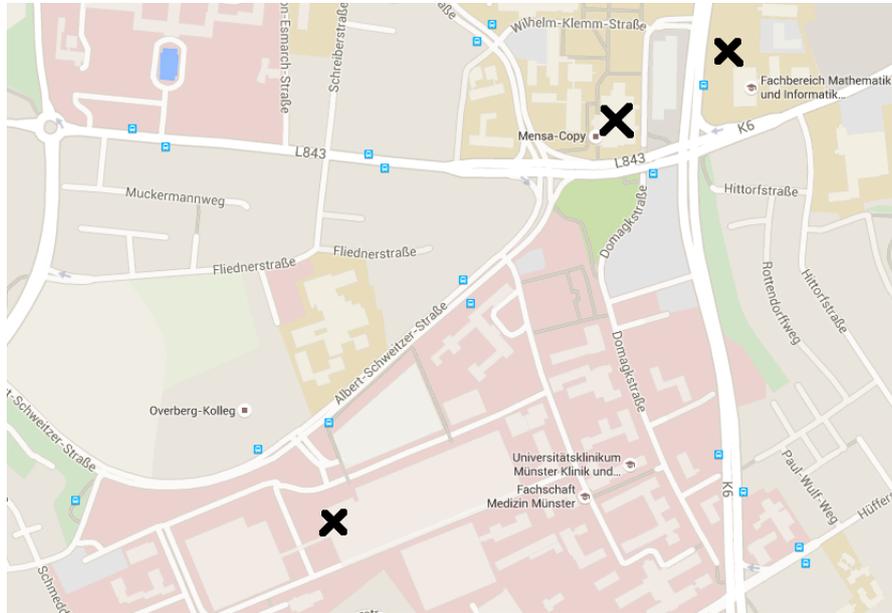
- Hotel am Schlosspark, Schmale Straße 2–4, D-48149 Münster
- Hotel Überwasserhof, Überwasserstraße 2, D-48143 Münster



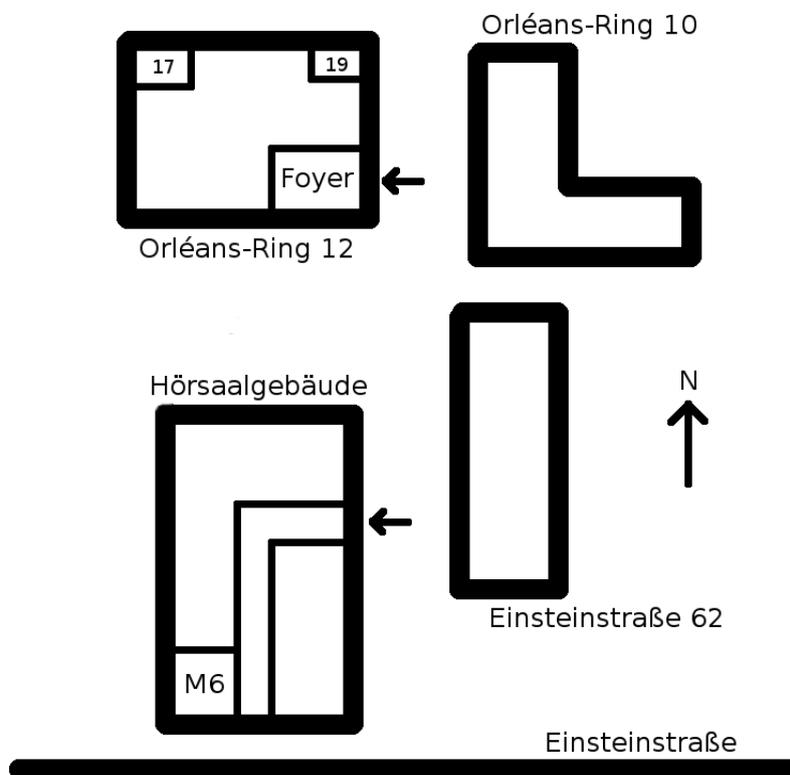
M = Mathematical institute, S = Hotel am Schlosspark, Ü = Hotel Überwasserhof.

4.3 Mathematics institute and lunch

The closest option for lunch is the nearby cafeteria/canteen/mensa, Mensa am Ring (immediately opposite the mathematics site). The cafeteria in the Uni-Klinik (on Albert-Schweitzer-Straße on the map below) is quite nice, but a longer walk.

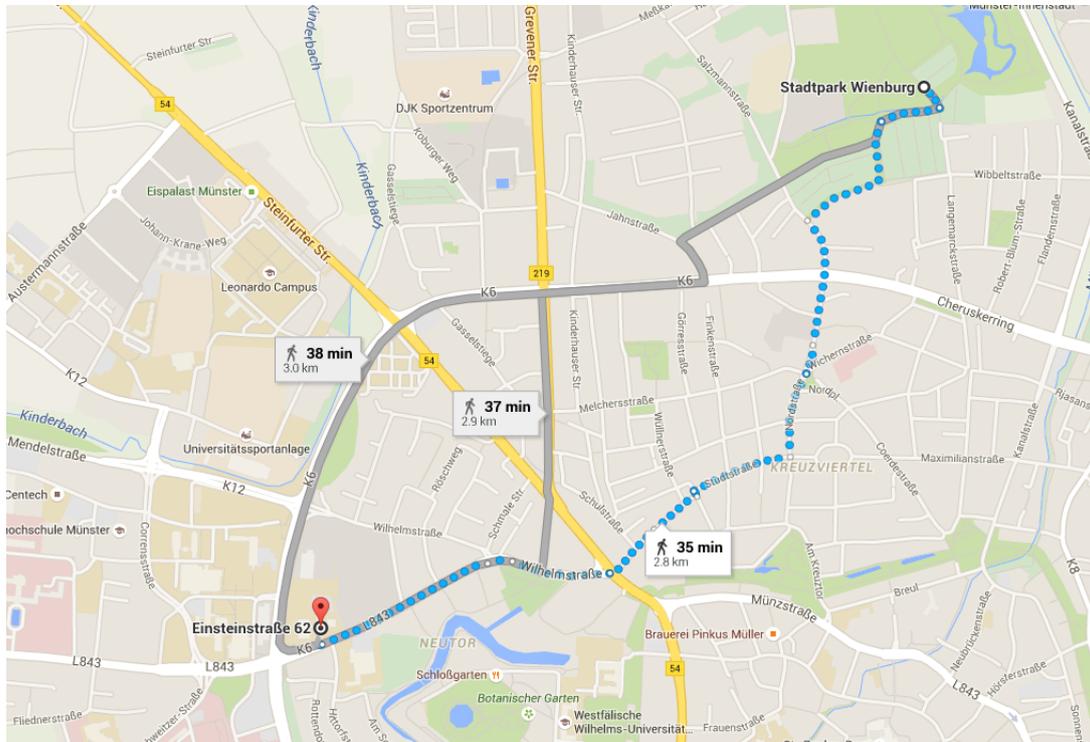


4.4 Ground plan of the mathematics buildings



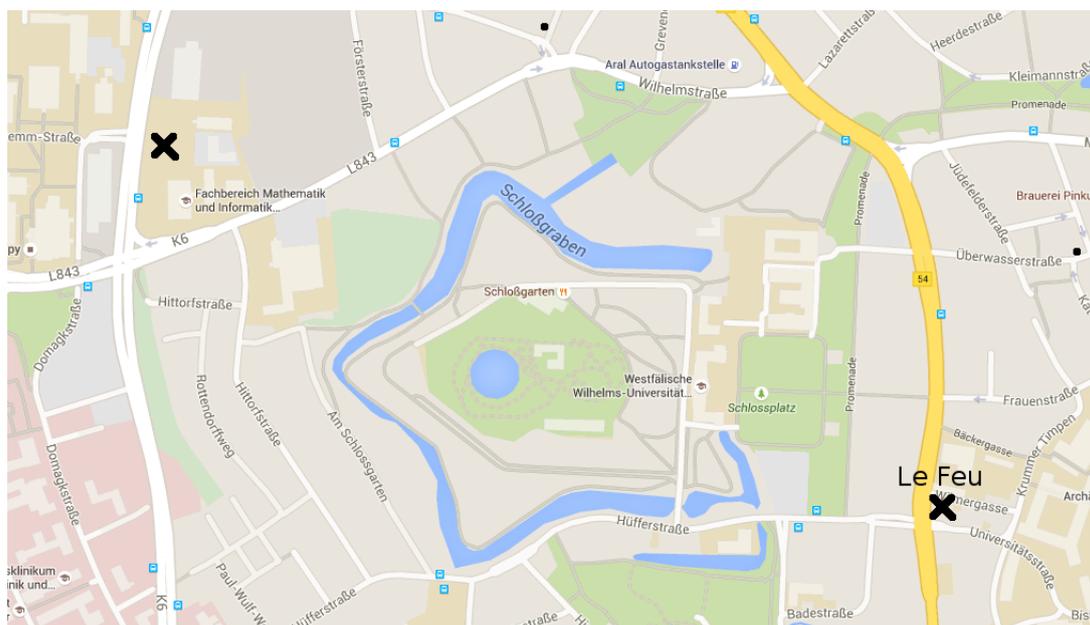
4.5 Barbecue

On Monday we will have a barbecue after the discussion session, at 7pm, in the Stadtpark Wienburg. Directions for getting there from the mathematics department are below.



4.6 Workshop dinner

On Thursday we will have the workshop dinner, at 6:30pm, at the restaurant *Le Feu*, which specialises in *Flammkuchen* (also *Flämmkiächa* or *tarte flambée*). Below is a map of its location relative to the mathematics department. Warning: it is (currently) incorrectly placed on Google Maps, so don't rely on that to find your way there!



4.7 Recommended restaurants, etc.

Restaurants

- Alter Pulverturm (Breul 9) – beer garden, on the Promenade
- Altes Gasthaus Leve (Alter Steinweg 37) – traditional Westphalian food
- Bar Celona (Stubengasse 17) – large brunch buffet (for anyone staying until Saturday)
- Buddha palace (Von-Esmarch-Straße 18) – Nepalese, Tibetan and Indian
- Drübbelken (Buddenstraße 14–15) – traditional Westphalian food
- Il Borgo (Grevener Straße 1) – very good Italian restaurant, near to the department
- Kruse Baimken (Am Stadtgraben 52) – very near the lake (Aasee)
- Le Feu (Schlossplatz 48) – see [above](#)
- Noites de Lisboa (Sonnenstraße 42) – Portuguese
- Phoenicia (Steinfurter Straße 37) – Lebanese
- Pinkus Müller (Kreuzstraße 4–10) – also a brewery
- Royals and Rice (Frauenstraße 51-52) – Vietnamese
- Zum Himmelreich (Annette-Allee 9) – next to the lake (Aasee)

Cafes

- Floyd Coffee (Domplatz 6) – facing the cathedral, close enough to university buildings to connect to eduroam
- Cafe Gasolin (Aegidiistraße 45)
- Roestbar Kreuzviertel (Nordstraße 2) – they brew their own coffee in Münster
- Roestbar Theater (Martinistraße 2) – another of their 4 cafes around Münster
- SpecOps (Von-Vincke-Straße 5) – open from 2pm until late, good collection of vegan cakes

Ice cream

- Raphaels Eis (Bült 1) – they often have interesting flavours, and also many sorbets
- Most streets in the city centre have at least one ice cream shop.

Bars

- Kreuzstraße has many bars, including the brewery Pinkus Müller.
- Alternatively, there is the Hafen (harbour) area, south-east from the station, which also has many bars – although it is the other side of Münster from the department.

Funfair

- The *Send* (or *Kirmes*, or funfair) will be in Münster from Thursday until next Monday, in the Schlossplatz, which is immediately opposite Le Feu (where we will have the conference dinner). On Thursday it will be open until 10pm, and on Friday there will be fireworks at 10:30pm. More information (in German) is here: www.stadt-muenster.de/send/startseite.html.



5. Excursions and bike hire

5.1 Wednesday afternoon

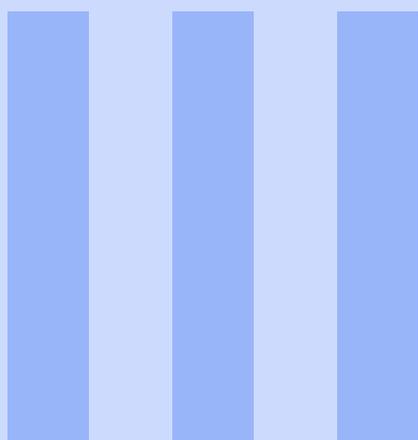
On Wednesday the afternoon will be free to allow some time to enjoy Münster. Highlights of the city and its surroundings include beautiful cycling routes,^{*} the Aasee lake, which has bars, beer gardens, a pleasant walk around the lake and opportunities to visit the zoo or open-air museum. More ambitious participants might like to hire a pedalo on the Aasee or even go canoeing along the Werse (a small river a short cycle ride to the east of Münster – pictured above). We hope to organise some of these activities depending on participants' interest, but you are of course welcome to spend the afternoon however you wish.

*A couple of recommended cycling routes are:

- To Burg Hülshoff (the birthplace of Annette von Droste-Hülshoff):
(www.gmap-pedometer.com/?r=6636580)
- To and along the Werse, to Cafe Nobis:
(www.gmap-pedometer.com/?r=6636591)

5.2 Bike hire

Immediately in front of the train station (the left-hand marker on the map in §4.1) is the *Radstation*, where one can hire bikes. They are open until 11pm every day, and bike hire costs 8€ per day or 37,50€ per week. Their website is here: radstation.de/de/mieten/4_2.html. Münster is a very bike-friendly city, with clearly marked bike lanes in red brick throughout the city.



List of participants

Name	Affiliation
Ricardo Andrade	University of Münster
Gregory Arone	University of Virginia
Miradain Atontsa Nguemo	Université catholique de Louvain
Eduard Balzin	Université de Nice; Higher School of Economics, Moscow
Lauren Ann Bandklayder	Northwestern University
Ilan Barnea	University of Münster
David Barnes	Queen's University Belfast
Tobias Barthel	Max Planck Institute for Mathematics
Georg Biedermann	Université Paris 13
Pedro Boavida de Brito	Université catholique de Louvain
Chris Braun	University of Münster
Federico Cantero	University of Münster
Michael Ching	Amherst College
Joana Cirici	Freie Universität Berlin
Jacques Darné	Université Paris 13
Aurélien Djament	Centre national de la recherche scientifique
Rosona Eldred	University of Münster
William Gollinger	University of Münster
Florian Göppl	University of Münster
Geoffroy Horel	University of Münster
Brenda Johnson	Union College
Jens Jakob Kjaer	University of Notre Dame
Ben Knudsen	Northwestern University
Pascal Lambrechts	Université catholique de Louvain
Filipp Levikov	Freie Universität Berlin
John Lind	University of Regensburg
Nina Otter	University of Oxford
Martin Palmer	University of Münster
Teimuraz Pirashvili	University of Leicester
J. D. Quigley	University of Notre Dame
Oliver Röndigs	University of Osnabrück
Carmen Rovi	University of Edinburgh
Oliver Sommer	University of Münster
Arthur Soulié	Université de Strasbourg
Paul Arnaud Songhafouo Tsopméné	Université catholique de Louvain
Markus Szymik	NTNU Norwegian University of Science and Technology
Steffen Tillmann	University of Münster
Victor Turchin	Kansas State University
Christine Vespa	IRMA Université de Strasbourg
Nathalie Wahl	University of Copenhagen
Michael Weiss	University of Münster
David White	Denison University
Christoph Winges	University of Münster
Calvin Woo	Indiana University
Abdoulkader Yacouba Barma	Université catholique de Louvain
Ivan Yudin	University of Coimbra