$(\text{BMS Student Conference})^6$

Conference Booklet
Berlin, February 21st - 23rd, 2018

Berlin Mathematical School

Welcome!

It is our pleasure to welcome you at Berlin to our 6th BMS Student Conference 2018, taking place from the 21st to the 23rd of February 2018. This document provides you with information concerning the conference, the social events and its surroundings. On the conference's webpage[1] you can find all the information on location, schedule and abstracts as well.

We would like to express our gratitude to all speakers for contributing to this conference, as well as to all participants for visiting Berlin to join our event. Special thanks to Prof. Pilar Bayer and Prof. Nicole Schweikardt for accepting our invitation.

If you have any questions feel free to contact the organization team. We wish you an insightful conference, an exciting time in Berlin.

Organizers

Héctor Andrade Loarca (TU Berlin)
Qiao Luo (TU Berlin)
Brent Moran (FU Berlin)
Yuya Tokuta (FU Berlin)
Josué Tonelli-Cueto (TU Berlin)

E-Mail

bmsstudconf@gmail.com

Special acknowledgments

We are thankful to Prof. Marta Macho-Stadler for providing the objects photographied for the poster and to Ms. Iris Grötschel and Prof. Martin Grötschel for signing and dedicating their book "Mathematical Berlin" for the invited speakers.

[1] https://bmsstudconf.github.io/2018

Program

There will be an introduction to the conference 15 minutes before the first talk.

	Wednesday 21st	Thursday 22nd	Friday 23rd
10:00-10:30	**Registration**		
10:30-11:00	Tonelli-Cueto	Hüttenhain	Rosati
11:00-11:30	Skrodzki	Kohn	Lynch
11:30-12:00	**Coffee/Tea/Whatever Break**		
12:00-12:30	Nicole Schweikardt	Pilar Bayer	Palić
12:30-13:00			Hackfeld
13:00-14:30	**Lunch**		
14:30-15:00	Vermeeren	Kolbe	
15:00-15:30	Affolter	Tóbiás	
15:30-16:00	**Coffee/Tea/Whatever Break**		
16:00-16:30	Stephan	Fairley	
16:30-17:00			
17:30-19:00	Botanical Garden		
18:30-24:00		Wine and Cheese	

Venue

The talks of the conference will take place at the Großer Hörsaal in the Institut für Informatik of the Freie Universität Berlin, at Takustr. 9, which is the building marked in the FU Campus Map on page 4.

How to get there?

There are several puplic transportation options:

- **Bus line X83**, at the stop **Arnimallee**.
- **Bus line 101**, at the stop **Limonenstraße**.
- **Bus line X11**, at the stop **Dahlem-Dorf**.

All the information above must be checked in the web of the public transportation system of Berlin `fahrinfo.bvg.de`.

Social Events

Guided Tour to the Botanical Garden

On Wednesday 21st February, there will be a guided tour to the Botanical Garden (Königin-Luise-Platz, 12203 Berlin) from 17:30 until 19:00. The meeting place for those attending the tour will be in front of the Institut für Informatik of Freie Universität Berlin, at Takustr. 9. From there we will start walking to the Botanical Garden at 16:45.

Wine and Cheese

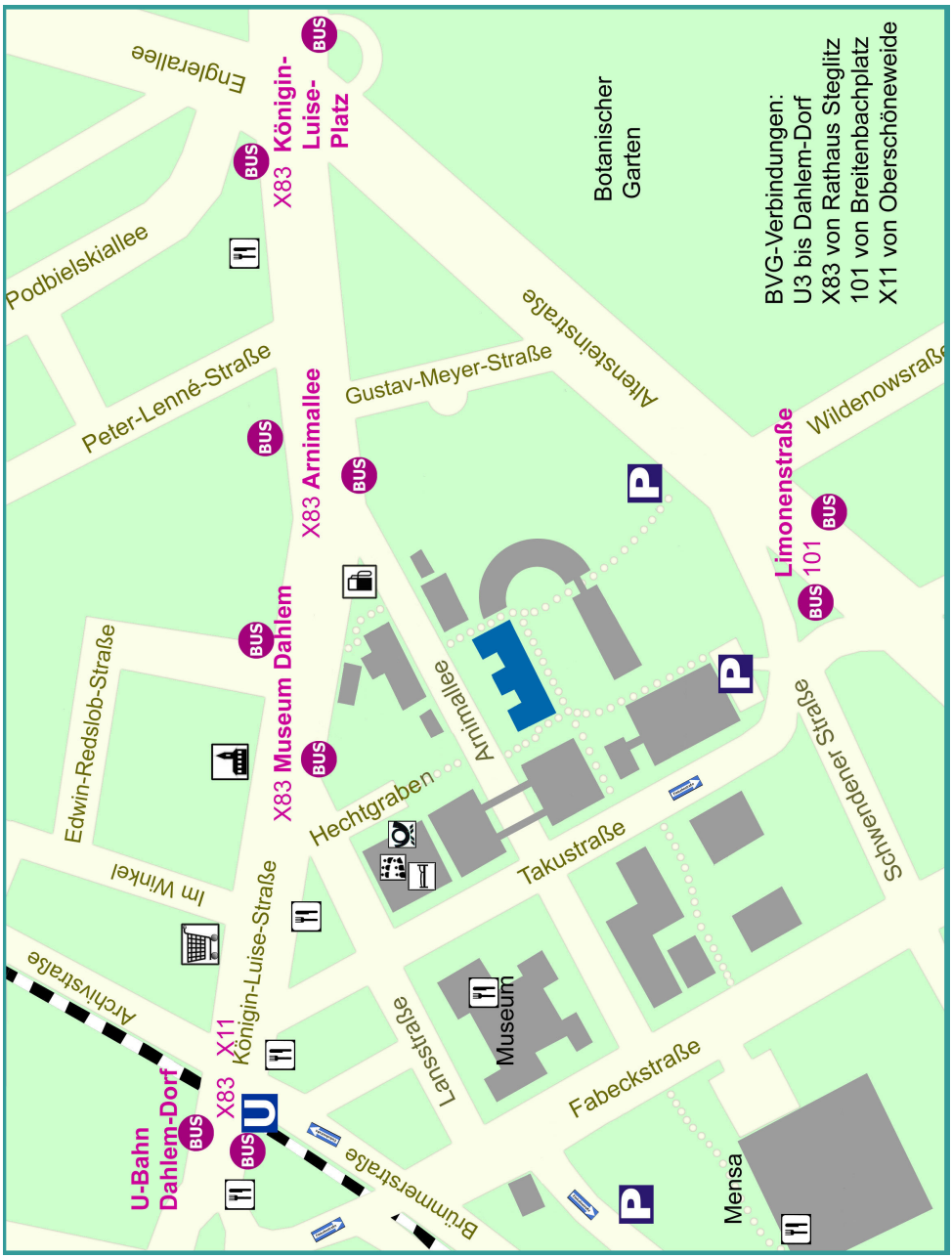
Our traditional Wine and Cheese evening will take place on Thursday 22nd February from 18:30 until 23:45 in the TU BMS Lounge (Straße des 17. Juli 136, 10623 Berlin, second floor Room 212).

Places to Eat

There are several options for lunch around the campus of the Freie Universität Berlin. These are some of them:

- **Mensa**, at Otto-von-Simson-Str. 26, 14195 Berlin. (Around 5€)
- **Julius-Kühn Institut Canteen**, at Königin-Luise-Straße 19, 14195 Berlin. (Around 5€)
- **Esskultur Restaurant in Dahlem Museum**, at Takustr. 38/40, 14195 Berlin-Steglitz. (Around 6€)
- **Dai Mai**, across from Dahlem-Dorf U-Bahn station. (Around 5€)
- **Best of Kebap**, adjacent to Dahlem-Dorf U-Bahn station. (Around 4€)
- **Luise Dahlem**, at Königin-Luise-Straße 40-42, 14195 Berlin. (10-20€)
- **Non La Restaurant**, at Grunewaldstraße 28, 12165 Berlin. (8-15€)
- **Asia Snack**, at Königin-Luise-Straße 38, 14195 Berlin. (3-6€)

FU Campus Map



The blue marked building is where the talks take place.

Abstracts - Invited Speakers

Wednesday 21st February, 12:00 - 13:00

The computational complexity of query answering under updates
Nicole Schweikardt *(HU Berlin)*

Query evaluation is one of the most fundamental tasks in databases, and a vast amount of literature is devoted to the complexity of this problem. This talk will focus on query evaluation in the "dynamic setting", where the database may be updated by inserting or deleting tuples. In this setting, an evaluation algorithm receives a query Q and an initial database D and starts with a preprocessing phase that computes a suitable data structure to represent the result of evaluating Q on D. After every database update, the data structure is updated so that it represents the result of evaluating Q on the updated database. The data structure shall be designed in such a way that it quickly provides the query result, preferably in constant time (i.e., independent of the database size). We focus on the following flavours of query evaluation.

(1) Testing: Decide whether a given tuple t is contained in Q(D).

(2) Counting: Compute the number of tuples that belong to Q(D).

(3) Enumeration: Enumerate Q(D) with a bounded delay between the output tuples.

Here, as usual, Q(D) denotes the k-ary relation obtained by evaluating a k-ary query Q on a relational database D. For Boolean queries, all three tasks boil down to

(4) Answering: Decide if Q(D) is non-empty.

Compared to the dynamic descriptive complexity framework introduced by Patnaik and Immerman (1997), which focuses on the expressive power of first-order logic on dynamic databases and has led to a rich body of literature, we are interested in the computational complexity of query evaluation. We say that a query evaluation algorithm is efficient if the update time is either constant or at most polylogarithmic in the size of the database.

In this talk I want to give an overview of recent results in this area.

Short Biography

Name: Nicole Schweikardt
Professor
at Humboldt-Universität zu Berlin
Link to personal webpage:
`https://www2.informatik.hu-berlin.de/~schweikn/`
Email Address:
schweikn@informatik.hu-berlin.de

Nicole Schweikardt currently is a professor at the department of computer science at Humboldt-University Berlin. She graduated in mathematics and computer science at Johannes Gutenberg-University Mainz in 1998 and received her PhD in computer science from the same university in 2002. Her main research interests are in logic, database theory, and complexity theory, with a focus on the complexity of processing massive datasets, efficient query evaluation, and the expressivity and complexity of query languages and logics. She has supervised 6 PhD theses and various research projects in these areas. She has given invited lectures and tutorial at leading conferences in the field, including the ACM Symposium on Principles of Database Systems (PODS), the International Conference on Database Theory (ICDT) and the International Symposium on Theoretical Aspects of Computer Science (STACS).

She has been a postdoctoral researcher at the University of Edinburgh (2002-2003) and Humboldt-University Berlin (2003-2007), and a professor at Goethe-University Frankfurt (2007-2014). Since 2014, she is a full professor at Humboldt-University Berlin, heading the logic in computer science group.

She was awarded the *GI-Dissertationspreis 2002*. In 2005 she received an *Emmy-Noether Independent Junior Research Group Leadership* and was selected as a member of the *Young Academy* (a joint project of Germany's two oldest academies, the Leopoldina and the Berlin-Brandenburg Academy of Sciences and Humanities). In 2007 she received the *Heinz Maier-Leibnitz-Preis*, and in 2015 she received the *teaching award* of the Faculty of Mathematics and Natural Sciences at Humboldt-University Berlin.

More information about the speaker on the conference's webpage.

Thursday 22st February, 12:00 - 13:00

Complex uniformization of Fermat curves

Pilar Bayer *(University of Barcelona)*

The ground-breaking research on the uniformization of complex algebraic curves was conducted in the early decades of the 19^{th} century. Nevertheless, there are few examples in the literature of algebraic curves for which an explicit uniformization is known. Prototypes are the circle, the elliptic curves and the modular curves. In particular, the modular curves $X_0(N)$ are uniformized by the functions $(j(z), j(Nz))$, where $j(z)$ stands for a complex function which is invariant for the action of the modular group $\mathrm{PSL}(2, \mathbb{Z})$. Our purpose will be to obtain explicit uniformizations of the Fermat curves $X^N + Y^N = Z^N$ by making use of functions which are invariant under the action of discrete groups acting on the complex upper half-plane. The talk is based in joint work with Jordi Guàrdia.

Short Biography

Name: Pilar Bayer
Emeritus Professor
at University of Barcelona
Link to personal webpage:
`http://www.ub.edu/tn/personal/bayer.php`
Email Address:
bayer@ub.edu
plrbayer@gmail.com

Pilar Bayer is currently Emeritus Professor of the Faculty of Mathematics and Computer Science at the University of Barcelona. She graduated in mathematics at the University of Barcelona in 1968 and obtained her PhD in mathematics at the same university in 1975. Previously, in 1967, she qualified as a piano teacher at the Municipal Conservatory of Music of Barcelona. Her research field is number theory. Her publications focus on zeta functions, diophantine equations, automorphic forms, elliptic curves, modular curves and Shimura curves. She has supervised 15 PhD theses and numerous research projects in these areas. She has given lectures, and seminars at universities and research centres in Austria, France, Germany, Greece, Poland, Portugal, Russia, Spain, and Tunisia.

She has been a lecturer at the University of Barcelona (1968-1975), Autonomous University of Barcelona (1969-1977; 1981-1982), Regensburg Universität (Germany, 1977-1980) and University of Cantabria (1980-1981). In 1982, she became full professor of Algebra at the University of Barcelona.

In 1998 she was awarded the *Narcís Monturiol Medal* for scientific and technological achievement by the Catalan government. In 2004 she was named *Emmy-Noether-Professorin* by the Georg-August-Universität Göttingen, Germany. In 2015 she has been awarded the *Honor Medal of the The Vives Network*.

More information about the speaker on the conference's webpage.

Abstracts - Student Talks

Wednesday 21st February, 10:30 - 11:00

The Niyogi-Smale-Weinberger Approximation Theorem
Josué Tonelli-Cueto *(TU Berlin)*

At the end of the 19th century, the artists Georges Seurat and Paul Signac developed the technique of pointillism, which is based in the idea that a continuous shape can be represented by a discrete cloud of points. This principle, which is the foundation of all screens, was incorporated almost a century later to what is known as Topological Data Analysis. However, how good can a cloud of points approximate a geometric object?

In this talk, we will review the Niyogi-Smale-Weinberger Approximation Theorem which relates how difficult is to approximate topologically a geometric object by a cloud of points to the geometric quantity known as reach.

Wednesday 21st February, 11:00 - 11:30

The Moving Least Squares Approach in Point Cloud Processing
Martin Skrodzki *(FU Berlin)*

The *Moving Least Squares* (MLS) approach is a powerful means to operate on point clouds. It has been investigated in great detail by David Levin in several papers and was already put to use in geometry processing and shape modeling. The goal of this talk is to briefly give an introduction to the MLS procedure and to report on some recent developments and applications of the method in the field of Point Cloud Processing.

Wednesday 21st February, 14:30 - 15:00

Modified equations and $\frac{\pi^2}{6}$
Mats Vermeeren *(TU Berlin)*

Numerical discretizations of differential equations are often studied through their modified equation. This is a differential equation, usually obtained as a power series, with solutions that exactly interpolate the discretization. By comparing the modified equation to the original equation, the error propagation of the numerical method can be studied.

When we consider a very simple discrete dynamical system – one which we can solve exactly – we can reverse the direction of the argument and use the discrete dynamics to understand the power series defining the modified equation. We use this method to derive the series expansion

$$\left(\arcsin\frac{h}{2}\right)^2 = \frac{1}{2}\sum_{k=1}^{\infty}\frac{(k-1)!^2}{(2k)!}h^{2k},$$

which can be used to prove the well-known identity

$$\sum_{k=1}^{\infty}\frac{1}{k^2} = \frac{\pi^2}{6}.$$

Wednesday 21st February, 15:00 - 15:30

Dynamics on integrable circle patterns
Niklas C. Affolter *(TU Berlin)*

Circle patterns are just a set of circles in the plane, where we consider some of the intersecting circles as neighbours and therefore gain an additional graph structure. As an example, any triangulation of the plane or disc yields a circle pattern via the set of its circumcircles. The special class of integrable circle patterns admits factorizing intersection angles. In this talk we will also discover several geometric properties of these patterns, and how they allow us to define dynamics on the triangular, the hexagonal and the square lattice. It turns out that these dynamics do not only preserve the given integrable structure, but at the same time conserve the "electric" properties of the patterns. In fact, they represent a geometric way of doing the classical Y-Δ move. This connects the patterns and the dynamics to statistical physics and to the modern notion of cluster algebras.

Wednesday 21st February, 16:00 - 16:30

On the Hamilton-Jacobi-Equation
Artur Stephan *(HU Berlin)*

In this talk, we derive the Hamilton-Jacobi-Equation

$$\begin{aligned} 0 &= \frac{\partial}{\partial t}S(x,t) + \mathbf{H}\left(\frac{\partial}{\partial x}S(x,t), x\right) \\ S(x,0) &= S_0(x), \end{aligned}$$

which describes the evolution of the action S of a physical system governed by the Hamiltonian **H**. This nonlinear first-order partial differential equation is fundamental in classical physics and has many applications in calculus of variation and geometry. Using methods from convex analysis, we present the fascinating method of E. Hopf for solving the Hamilton-Jacobi-Equation in the potential free case.

Thursday 22nd February, 10:30 - 11:00

Orbit Closures of Homogeneous Forms
Jesko Hüttenhain

The **P** versus **NP** question is among the most prestigeous of modern mathematics, but deemed out of reach by many of the leading researches in the field. Less widely known is its algebraic analogue, the question of **VP** versus **VNP**. We will present the problem and a recent approach to it known as Geometric Complexity Theory, which transitions from computational complexity to algebraic geometry and representation theory. If time permits, the speaker will present some results from his PhD thesis (at TU Berlin) in this context.

Thursday 22nd February, 11:00 - 11:30

Changing Views on Curves and Surfaces
Kathlén Kohn *(TU Berlin)*

One of the major problems in computer vision is the detection of visual events. We study such events from the perspective of algebraic geometry. For this, we take pictures of a moving curve or surface, which means to consider its image or contour curve that arises by projecting from different viewpoints. Qualitative changes in that curve occur when the viewpoint crosses the visual event surface. We examine the components of this ruled surface, observe that these coincide with the iterated singular loci of the coisotropic hypersurfaces associated with the original curve or surface, and show how to compute exact representations for all visual event surfaces using algebraic methods.

Thursday 22nd February, 14:30 - 15:00

Entangled Nets from Surface Drawings
Benedikt KOLBE *(TU Berlin)*

Imagine drawing lines on a surface. Most of us are pretty lazy, so we most likely manage only a small doodle. However, what if the drawing for the rest of the surface can be filled in by invoking symmetries. If the surface we are drawing on is arbitrary, what are all the ways we can scribble such that this actually works? Is there a way to enumerate these different ways? If the goal was to find molecular structures by drawing them on surfaces, what surfaces would we start with and why?

The first and greater part of my talk will motivate and answer these questions, while focusing on a new technique to explicitly enumerate and construct all essentially different ways to decorate prominent examples of triply periodic minimal surfaces.

The second part will focus on what we can say about the kinds of structures that arise from this process and the kind of advantages this new approach offers. This is a rather controversial topic, as most chemists exclusively use crystallographic tables for the study of symmetries in 3D structures.

There will be tie-ins to geometry, braid theory, combinatorial group and tiling theory, physics, and even some chemistry.

Thursday 22nd February, 15:00 - 15:30

A Gibbsian model for message routing in highly dense wireless networks
András TÓBIÁS *(TU Berlin)*

In spatial telecommunication networks, it is a prominent question how to route many messages in the same time. We propose a random mechanism to choose the trajectories of messages in a network, where users are situated randomly in a compact subset of $\mathbb{R}^d$, and each user sends one message to the single base station. Messages are transmitted either directly or via other users, with a given upper bound on the number of hops. We define a Gibbsian probability measure on the set of such trajectory families, which favours trajectories with little interference (measured in terms of the signal-to-interference ratio (SIR)) and trajectory families with little congestion (measured in terms of the number of pairs of incoming messages of the users).

We derive the behaviour of this system in the limit of a high spatial

density of users using a large-deviation analysis, and provide a law of large numbers for the empirical measure of message trajectories. The limit of these empirical measures is given as the minimizer(s) of a characteristic variational formula. In the special case when congestion is not penalized, we analyze this minimizer and investigate the questions of the typical number of hops, the typical length of a hop and the typical shape of a trajectory in the highly dense telecommunication system.

The topic of this talk is joint work with my supervisor Wolfgang König.

Thursday 22nd February, 16:00 - 16:30

Touching Conics
Alexander Fairley *(FU Berlin)*

On a theorem about conics. The theorem is useful for constructing images of touching conics. The construction can be described in terms of a point particle that is moving inside a conic. The particle moves in a straight line which is reflected when the particle hits the conic. Circles, inscribed in quadrilaterals, make an unexpected appearance when the particle's trajectory obeys a familiar law of geometric optics.

The talk is based on personal work. However, I benefitted from a discussion with Prof. Bobenko on [1].

[1] A.V. Akopyan, A.I. Bobenko. *Incircular nets and confocal conics*, Trans. AMS, 2017.

Friday 23rd February, 10:30 - 11:00

KPZ Equation
Tommaso Cornelis Rosati *(HU Berlin)*

In 1986, the three physicists Mehran Kardar, Giorgio Parisi, and Yi-Cheng Zhang derived a stochastic partial differential equation whose solution describes the fluctuations of the boundary separating two competing materials. This model found a wide range of applications, from describing the expansion of a forest fire to the interface separating water from ice. Recently there has been an increasing interest in the KPZ equation, since it partially motivated the development of the theory of regularity structures, which aims at tackling certain classes of ill-posed stochastic PDEs. Surprisingly, this solution theory dives deep in the field of stochastic analysis, providing new ways to understand the stochastic integral, a central object in probability theory. I

will present one (or maybe two) ideas behind this theory, show some pictures referring to the KPZ equation and very briefly explain my work, namely the construction of a solution on the whole real line.

Friday 23rd February, 11:00 - 11:30

Convexity and curvature
Stephen Lynch *(FU Berlin)*

One need not distinguish between convexity and positive curvature in the case of compact hypersurfaces in Euclidean space - the two notions are equivalent. This freedom of perspective is useful not only because convexity is a completely extrinsic condition, and the curvature completely intrinsic. Moving from hypersurfaces to submanifolds of higher codimension, Jordan abandons us, and convexity no longer makes sense. In the talk, we will consider an extrinsic 'pinching' condition for submanifolds of Euclidean space which generalises convexity in at least two ways: firstly, it forces positivity of the curvature, and secondly, pinched solutions to the mean curvature flow behave exactly like convex solutions.

Friday 23rd February, 12:00 - 12:30

Cutting a part from many measures
Nevena Palić *(FU Berlin)*

Measure partitions are challenging problems in topological combinatorics. Given a collection of measures in a Euclidean space, the question is whether there exists a partition of the ambient space, such that it cuts the measures in a prescribed way. One of the best known measure partition results is the Ham Sandwich theorem proved by Banach in 1938, that states that any collection of d measures in $\mathbb{R}^d$ can be cut by a hyperplane, so that each measure gets partitioned into two equal parts.

In this talk a short survey of measure partition results will be presented and some methods from topological combinatorics will be explained on the example of the paper *Cutting a part from many measures*, arXiv:1710.05118.

We prove a continuous analogue of the conjecture of Holmsen, Kynčl and Valculescu about partitions of finite colored sets. Indeed, for integers m, c and d and a prime power $n = p^k$ such that $d \geq 2$ and $m \geq n(c-d)+\frac{dn}{p}-\frac{n}{p}+1$, and for m positive finite absolutely continuous measures $\mu_1, \ldots, \mu_m$ on $\mathbb{R}^d$, we prove that there exists a partition of $\mathbb{R}^d$ into n convex sets, such that

every set has positive measure with respect to at least c of the measures $\mu_1, \ldots, \mu_m$. Additionally, we obtain an equipartition of the measure μ_m.

The proof relies on a configuration space/test map scheme that will be the main part of this talk. It translates the problem into a novel question from equivariant topology – a non-existence of $\mathfrak{S}_n$-equivariant maps from the ordered configuration space of n points in $\mathbb{R}^d$ into the union of an arrangement of affine subspaces of a Euclidean space.

Joint with Pavle V. M. Blagojević and Günter M. Ziegler.

Friday 23rd February, 12:30 - 13:00

Space-optimal collaborative exploration of undirected graphs
Jan Hackfeld *(HU Berlin)*

In graph exploration, one or more so-called agents or robots have to deterministically visit all vertices of a given unknown graph. In this talk, we investigate the memory requirement for multiple cooperative agents to explore an undirected graph. We show that $\Theta(\log \log n)$ agents with only constant memory are necessary and sufficient to explore any graph with at most n vertices.