Report for the African Mathematical School
Introduction to Number Theory, Cryptography and related courses

September 06-19, 2021

AIMS Senegal, Mbour, Senegal

The African Mathematical School *Introduction to Number Theory, Cryptography and related courses* took place at AIMS Senegal, Mbour, from September 06 to 19, 2021. Initially scheduled in 2020, it had to be postponed to 2021 because of the Covid pandemic. The website of the school is:

http://www.rnta.eu/Senegal2020/

The objective of the school was to provide participants with mathematical foundations and essential tools in number theory and cryptography, to put them in touch with African and non-African research mentors on these topics, and to promote the exchange of knowledge between African and non-African mathematicians.

The school gathered 40 persons on-site (see Appendix 4 for the complete list):

- 33 participants: Bachelor students, Master students, and PhD students/postdocs in Mathematics, in equal proportions. Among them:

  66% were from Senegal and 34% from other West African countries (Benin, Burkina Faso, Guinea, Ivory Coast, Nigeria),

  42% were women and 58% were men,

- 7 lecturers or main organizers: confirmed mathematicians from France, Senegal, South Africa, and USA. Among them, two were women and also the main organizers.

In the course of both weeks, 46 hours of lectures were delivered (see Appendixes 1 and 2 for the list of lecturers and courses, and the time schedule). Two lecturers from France and Italy were not able to attend the event but gave their course online using Zoom. Besides the lectures, we hosted contributions in a less classical format:

- four 30-minute research presentations given by selected participants (Guy Mobouale WAMBA, Euloge TCHAMMOU, Pape Modou SARR, Charles TOUGMA); they were unanimously appreciated for their mathematical interest and expository qualities,

- extended initiations to Python and SageMath[1], on selected topics in relation with the mathematical content of some of the courses (about 10 hours of practical sessions),

- a demonstration of SimulaMath[2], a free software for visualizing mathematics and solving mathematical problems, which aims at high-school students and teachers, and is being developed by Dr. Michel Seck in Senegal.

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[1] https://www.sagemath.org
[2] https://simulamath.org

The lectures took place in a comfortable classroom with two white screens/videoprojectors, two blackboards and Wifi connection. Each participant had a desk with a PC provided by AIMS, equipped with Ubuntu, Python and SageMath (some participants also brought their own laptop). Online courses on Zoom and practical sessions were made possible thanks to the very good computer equipment and internet connection at AIMS Senegal.

The main language of the school was initially English. However many participants had no proficiency in English and one participant from Nigeria could not understand French. We decided to switch to a multilingual school: English, French, sometimes both, were used by the lecturers.

The school started with an opening ceremony in the presence of Professors Mariama Ndiaye Diakhaby (Université Gaston Berger, Senegal), Mouhamed Ben Maaouia (Université Gaston Berger, Senegal), Ngalla Djitté (Université Gaston Berger, Senegal, Directeur de l'École Doctorale des Sciences et des Technologies), Moustapha Fall (President of AIMS Senegal) and Alain Togbe (Purdue University Northwest, USA, and lecturer of the school). The closing ceremony was devoted to delivering attendance certificates to the participants in the presence of Professor Moustapha Fall.

At this period – before the new academic year – we were able to benefit from the accommodation facilities at AIMS: shared rooms in the student residence, single rooms in the professor residence, with all the necessary comfort and Wifi connection, within a short walking distance from AIMS and at a very affordable price (15€ for a student, 30€ for a professor per weekday). This explains why the total budget of this school is significantly lower than for other similar events, and we are very grateful to AIMS for having given us access to these facilities.

Breakfasts and dinners were taken at the housing residences, lunches and coffee breaks at AIMS. A lunch–excursion at the Bandia natural reserve took place on the first weekend, and a social dinner at Saly on the second week. The drivers of AIMS took care of some of our small daily trips during the school, and transportation to and from Dakar airport.

Because of the Covid pandemic, entering Senegal from abroad at this time was subject to travel limitations, except for people from CEDEAO[3]/ECOWAS[4] (which was the case of all selected participants). Some foreign lecturers had to request in advance a special authorization from the Senegalese embassy to be able to enter the country.

Fortunately the situation regarding the pandemic was not critical in Senegal in September 2021 when the school took place. Participants who travelled from abroad had to take Covid tests before each flight. We also decided to test all local participants upon their arrival at AIMS to avoid any risk of local contagion. The school went well in this regard. Nevertheless these health measures had significant organizational impact (waiting time at the Covid test center, which could be of several hours) and total cost (about 1,500€) for the school.

We are very grateful to AIMS Senegal for hosting and supporting the school, helping immensely with the organization, providing excellent housing and working conditions, and a very pleasant environment, and for the availability and professionalism of all its staff. We are also very indebted to Professor Moustapha Fall for supporting financially the school through the Humboldt Chair.

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[3]Communauté économique des États de l'Afrique de l'Ouest
[4]Economic Community of West African States

This African Mathematical School is part of an intensive 5-week training research program in number theory and cryptography organized at AIMS Senegal in 2021/22. The program also consists of:

- the workshop *Women in Sage in Senegal* (one week, September 20 to 24, 2021)

- the CIMPA School *Cryptography, theoretical and computational aspects of Number Theory* (two weeks, June 27 to July 08, 2022)

The objective of this program is to attract new PhD students, to develop and nurture scientific exchanges on algebra, number theory and cryptography in this region of Africa, in particular research collaborations and co-supervision of PhD theses between African mathematicians and with non-African mathematicians. This program has received dedicated funding from the CNRS through the SENAREX project (see Appendix 3 for the financial report).

The workshop took place the week following the African Mathematical School. Selection of the participants was coordinated by the organizers. Eight participants, mostly women, attended both events and made the most of them.

An anonymous survey conducted after the school showed that the participants were very satisfied in general. Some mentioned their interest in discovering Python and SageMath. For other, the school made them realize the importance of the English language in science and pushed them to read documents in English now. Several mentioned that the school brought them extra motivation to pursue their studies in mathematics, or to start a master of PhD program in number theory/cryptography. Most of them insisted on the importance of making contact with new people – confirmed mathematicians or other participants — with similar mathematical interests, and its potential mid-term impact for them.

We believe this school was a great success. Our next step will be the CIMPA school next year. We would like to warmly thank all the institutions and organizations that have supported it and contributed to its success, in particular the CIMPA for its generosity. The list of all financial supports and detailed use of the CIMPA subvention is in Appendix 3.

The organizers,

Cécile Armana,
Assistant Professor, University of Franche-Comté, France, `cecile.armana@univ-fcomte.fr`

Bernadette Faye,
Assistant Professor, University Gaston Berger at Saint-Louis, Senegal `bernadette.fayee@gmail.com`

Appendix 1: List of courses and lecturers

Each course was 8×50 min. A list of bibliographical references and recommended readings was given to the participants a couple of weeks before the school.

- *Algebraic Number Theory*, Francesco Pappalardi (Università degli Studi Roma Tre, Italy)
- *Galois Theory*, Alain Togbe (Purdue University Northwest, USA)
- *Group Theory*, Florian Luca (University of the Witwatersrand, South Africa)
- *Introduction à la cryptographie*, Abderrahmane Nitaj (Université de Caen, France)

- *Introduction to Cryptographic Proof Techniques*, Augustin Sarr (Université Gaston Berger de Saint-Louis, Senegal)
- *Introduction to Number Theory based Cryptography*, Djiby Sow (Université Cheikh Anta Diop, Senegal), practical sessions by Michel Seck (Université Cheikh Anta Diop, Senegal)
- *Introduction to SageMath*, Cécile Armana (Université de Franche-Comté, France) (mostly practical sessions)

Appendix 2: Schedule

EMA/AMS Introduction to Number Theory, Cryptography and related courses
version of Sept 02, 2021

Times are indicated in Senegal (GMT+0). France/Italy are GMT+2 (add 2 to the hours indicated below).

First week (September 06 to 11, 2021)

Time	Monday 06	Tuesday 07	Wednesday 08	Thursday 09	Friday 10	Saturday 11
9h30-10h20	Opening ceremony	Togbe	Luca	Togbe	Togbe	Projects / exercises
10h30-11h20		Pappalardi *online*	Pappalardi *online*	Luca	Luca	
11h20-11h50	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break	
11h50-12h40	Togbe	Togbe	Luca	Togbe	Pappalardi *online*	
13h-14h30	Lunch break	Lunch break	Lunch break	Lunch break covid tests ?	Lunch break	Lunch/ excursion
14h30-15h20	Pappalardi *online*	Luca	Nitaj *online*	Pappalardi *online*	Togbe	Excursion Réserve de Bandia
15h20-15h50	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break	
15h50-16h40	Togbe	Pappalardi *online*	Nitaj *online*	Nitaj *online*	Pappalardi *online*	
16h50-17h40		Luca	Pappalardi *online*	Luca	Luca	
17h50-18h40		Research presentation		Nitaj *online*		

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Second week (September 13 to 18, 2021)

Time	Monday 13	Tuesday 14	Wednesday 15	Thursday 16	Friday 17	Saturday 18
9h30-10h20	Sarr	Sarr	Sarr	Armana	Armana	
10h30-11h20	Armana	Armana	Sow	Sow	Sow	Distraction / Departure
11h20-11h50	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break	
11h50-12h40	Sarr	Sarr	Sow	Sow	Sow	
13h-14h30	Lunch break	Lunch break	Lunch break covid tests ?	Lunch break covid tests ?	Lunch break	Lunch break
14h30-15h20	Armana	Armana	Nitaj *online*	Nitaj *online*	Armana	
15h20-15h50	Coffee break	Coffee break	Coffee break	Coffee break	Projects / exercises	
15h50-16h40	Sarr	Sarr	Nitaj *online*	Sow		
16h50-17h40	Sarr	Armana	Sow	Nitaj *online*		
17h50-18h40		Research presentation	Conference dinner at Saly			

Appendix 3: Financial report

Detailed expenses:

Plane tickets for 10 participants from abroad (West Africa)	5298.02€
Plane tickets for 4 participants from Senegal	511.60€
Plane tickets for 3 lecturers from abroad (France, South Africa, USA)	2300.77€
Local transportation for Senegalese participants and lecturers	1236.64€
Accommodation for participants and lecturers	5648.85€
Meals for participants and lecturers	5349.70€
Coffee breaks	1082.06€
Logistics	1256.00€
Covid tests for participants, and one lecturer from South Africa	1577.48€
Total	*24261.13€*

Sources and amount of spent funding:

AIMS Senegal and Humboldt Research Chair	6,703.30€
CNRS (France) – SENAREX project (*)	6,308.46€
CIMPA	**5,277.05€**
Foundation Compositio Mathematica	2,000€
International Mathematical Union – CDC	1,896.20€
CEA-MITIC[5](Université Gaston Berger, Senegal)	1,526.72€
Project Région Bourgogne Franche-Comté GACROCOCO (France)	549.40€
Total	*24,261.13€*

(*) SENAREX (écoles SENégalaises en ARithmétique et mathématiques EXplicites) is a two-year project funded by CNRS as a result of the call for proposals *Dispositif de Soutien aux Collaborations avec l'Afrique subsaharienne.* Led by Cécile Armana and Bernadette Faye, it will contribute to funding three mathematical schools that will be held at AIMS Senegal in 2021/22: this African Mathematical School, the workshop *Women in Sage in Senegal*, and the CIMPA school in 2022.

The CIMPA subvention was used for the following expenses:

- Plane tickets of 4 participants: Gisèle ETCHIO (Benin), Hine Ange Phinées GAHOUROU (Ivory Coast), Charles TOUGMA (Burkina Faso), Angoua Laurent WASSA (Ivory Coast): 1,456,400 XOF (2,234.51€)

- Meals for 4 participants: 258,070 XOF (394€)

- Coffee breaks for all participants: 708,750 XOF (1,082.06€)

- Covid tests for all participants and one speaker from developing countries: 1,033,248 XOF (1,577.48€).

Total of expenses on the CIMPA subvention: 3,456,468 XOF (5,277.05€).

The difference (1,222.95€) with the allocated subvention (5000€+1,500€) is due to last-minute cancellations of participants from Senegal and abroad.

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[5]Centre d'Excellence Africain en Mathématiques, Informatique et TIC

Appendix 4: list of participants

Last name	First name	M/F	Institution	Country	Status		Email
ADEGBINDIN	Chefiath Awero	F	Institut de Mathématiques et de Sciences Physiques	Benin	Postdoctoral student	P	adegbindinchefiath@gmail.com
BA	Fama Sène	F	Université Gaston Berger de Saint Louis	Senegal	Bachelor student	P	fresh14099@gmail.com
CAMARA	Moustapha	M	Université Assane Seck de Ziguinchor	Senegal	PhD student	P	m.camara5367@zig.univ.sn
CISSE	Ndéyé Khady	F	Université Gaston Berger de Saint Louis	Senegal	Bachelor student	P	cissendeyekhady398@gmail.com
DIALLO	Ablaye	M	Université Gaston Berger de Saint Louis	Senegal	Master student	P	diallo.ablaye@ugb.edu.sn
DIALLO	Boubacar Baïlo	M	Université Gaston Berger de Saint Louis	Senegal	Master student	P	boubacarbailo226@gmail.com
DIALLO	Houley	F	Université Cheikh Anta Diop	Senegal	Master student	P	hayleydiallo95d7@gmail.com
DIAW	Malick	M	Université Alioune Diop de Bambey	Senegal	Master student	P	diawmalick97@gmail.com
DIOP	Fatou	F	Université Gaston Berger de Saint Louis	Senegal	Master student	P	fatoudiop1595@gmail.com
ETCHIO	Gisèle	F	Université d'Abomey Calavi	Benin	Bachelor student	P	etchiogisele95@gmail.com
FAYE	Mariama Ndao	F	Université Gaston Berger de Saint Louis	Senegal	Master student	P	fayemariamandao@gmail.com
GAHOUROU	Hine Ange Phinées	F	Université Nangui Abrogoua	Ivory Coast	Master student	P	hineangephineesgahourou@gmail.com
GUEYE	Alioune	M	Université Gaston Berger de Saint Louis	Senegal	Bachelor student	P	gueye.alioune2@ugb.edu.sn
HANE	Marie Diamy	F	Université Gaston Berger de Saint Louis	Senegal	Bachelor student	P	hanemariediamy@gmail.com
KEUMEAN	Dekpassi Leopold	M	Université Félix Houphouet Boigny	Ivory Coast	PhD student	P	dekpassileo@gmail.com
KONTEYE	Ibrahima	M	Université Gaston Berger de Saint Louis	Senegal	Bachelor student	P	ikonteye9@gmail.com
MANGA	Marie Laure Sikème	F	Université Assane Seck de Ziguinchor	Senegal	Bachelor student	P	marielauresikeme@gmail.com
MBOOUALE WAMBA	Guy	M	Université Cheikh Anta Diop	Senegal	PhD student	P	wambastorm@gmail.com
NANSOKO	Souleymane	M	Institut de Mathématiques et de Sciences Physiques	Benin/Guinea	PhD student	P	soulnans@gmail.com
NDIAYE	Dié Fall	F	Université Gaston Berger de Saint Louis	Senegal	Bachelor student	P	die78432@gmail.com
OGUNDIPE	Opeoluwa	M	University of Ibadan	Nigeria	PhD student	P	opeogundipe2002@yahoo.com
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TCHAMMOU	Bagnantissoun Euloge	M	Institut de Mathématiques et de Sciences Physiques	Benin	Postdoctoral student	P	euloge.tchammou@imsp-uac.org
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TOUGMA	Charles Wend-Waoga	M	Université Thomas Sankara	Burkina Faso	Postdoctoral student	P	tougmacharles@yahoo.fr
TOURE	Ismaila	M	Université Gaston Berger de Saint Louis	Senegal	Bachelor student	P	ismatoure8@gmail.com
WADE	Ndeye Khady	F	Université Gaston Berger de Saint Louis	Senegal	Bachelor student	P	wadekhadija17@gmail.com
WASSA	Angoua Laurent	M	Université Nangui Abrogoua	Ivory Coast	Master student	P	wassa.laurent@univ-na.ci
ARMANA	Cécile	F	Université de Franche-Comté	France	Assistant Professor	O/L	cecile.armana@univ-fcomte.fr
FAYE	Bernadette	F	Université Gaston Berger de Saint Louis	Senegal	Assistant Professor	O	bernadette.fayee@gmail.com
LUCA	Florian	M	University of the Witwatersrand	South Africa	Professor	L	florian.luca@wits.ac.za
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SARR	Augustin Pathé	M	Université Gaston Berger de Saint Louis	Senegal	Professor	L	aug.sarr@gmail.com
SECK	Michel	M	Université Cheikh Anta Diop	Senegal	Assistant Professor	L	mseck@ept.sn
SOW	Djiby	M	Université Cheikh Anta Diop	Senegal	Professor	L	sowdjibal@yahoo.fr
TOGBE	Alain	M	Purdue University Northwest	USA	Professor	L	atogbe@pnw.edu

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Appendix 5: Poster and some pictures