

# Shibam GHOSH

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I have submitted my **PhD** thesis in the **Department of Computer Science** at the **University of Haifa**, under the supervision of **Prof. Orr Dunkelman**. I began my doctoral studies in October 2020. Before this, I completed my master's thesis as a research intern at **INRIA, Paris**, under the guidance of **Anne Canteaut** and **Léo Perrin**.

## Research Interests

- Cryptanalysis of Symmetric-key Primitives
- Symmetric-key Primitive Design
- Lightweight Cryptography
- White-box Cryptography
- Provable Security

## Education

### Indian Statistical Institute

MASTER OF TECHNOLOGY IN CRYPTOLOGY AND SECURITY

Kolkata, India

2018 – 2020

### Presidency University

MASTER OF SCIENCE IN MATHEMATICS

Kolkata, India

2015 – 2017

### Krishnagar Government College

BACHELOR OF SCIENCE IN MATHEMATICS

Krishnagar, India

2012 – 2015

## Research Experience

### University of Haifa

PHD STUDENT

Haifa, Israel

Oct 2020 – Dec 2024

- Supervisor: **Prof. Orr Dunkelman**
- My PhD research has centered on cryptanalysis, focusing on the design and analysis of symmetric primitives.
- A significant portion of my work is dedicated to the algebraic cryptanalysis of these primitives. Some key contributions:
  - An enhanced Fast Fourier Transform-based key-recovery attack on 6-round **AES**.
  - Algebraic cryptanalysis of NIST LwC candidates **Ascon**, **KNOT**, and **TinyJAMBU**.
  - Distinguishers derived from the structural symmetry of **SHA3**, **Xoodyak**, and the Belarusian standard **bash**.
  - Division property-based fault attacks on the **GIFT** and **Present** ciphers.
- In addition to cryptanalysis, I have co-designed the tweakable block cipher **QARMAv2**, tailored for memory protection.
- My research also extends into the area of re-keying techniques, where I have analyzed the security of the IETF/ISO standard Advanced CryptoPro Key Meshing (**ACPKM**) internal rekeying technique, widely used in Russian variants of TLS and CMS.

### Institut national de recherche en sciences et technologies du numérique (INRIA)

RESEARCH INTERN

Paris, France

Jan – July, 2020

- Supervisor: **Anne Canteaut**, **Léo Perrin**
- Master's Dissertation: On the QIC of quadratic APN functions (available online [here](#))
- My master's research focused on cryptographic Boolean functions, with particular emphasis on the Big APN Problem.
- Our goal was to generate quadratic APN functions of size  $\geq 8$ .
- The search for APN permutations and their classification has been an open challenge for over 25 years.
- Our core approach involved representing a quadratic vectorial Boolean function using a cubic structure called a Quadratic Indicator Cube (QIC) and identifying the criteria associated with this cube that are necessary and sufficient for a function to be APN.

# Publications

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## JOURNAL ARTICLES

1. Sahiba Suryawanshi, Shibam Ghosh, Dhiman Saha, and Prathamesh Ram. Simple Vs Vectorial: Exploiting Structural Symmetry to Beat the ZeroSum Distinguisher Applications to SHA3, Xoodyak and Bash. *IACR Cryptol. ePrint Arch.*, page 52, 2024 (Accepted to Design, Codes and Cryptography, [DOI](#)).
2. Roberto Avanzi, Subhadeep Banik, Orr Dunkelman, Maria Eichlseder, Shibam Ghosh, Marcel Nageler, and Francesco Regazzoni. The QARMAv2 Family of Tweakable Block Ciphers. *IACR Transactions on Symmetric Cryptology*, 2023(3):25–73, 2023 ([DOI](#))
3. Orr Dunkelman, Shibam Ghosh, and Eran Lambooj. Practical Related-Key Forgery Attacks on Full-Round TinyJAMBU-192/256. *IACR Trans. Symmetric Cryptol.*, 2023(2):176–188, 2023 ([DOI](#))
4. Orr Dunkelman, Shibam Ghosh, and Eran Lambooj. Attacking the IETF/ISO Standard for Internal Re-keying CTR-ACPKM. *IACR Trans. Symmetric Cryptol.*, 2023(1):41–66, 2023 ([DOI](#))

## CONFERENCE PAPERS

1. Ravi Anand, Shibam Ghosh, Takanori Isobe, and Rentaro Shiba. Quantum Key Recovery Attacks on 4-Round Iterated Even-Mansour with Two Keys. In *Proceedings of Information Security Conference (ISC)*, volume 15257 of *Lecture Notes in Computer Science*, pages 87–103. Springer, 2024 ([DOI](#))
2. Orr Dunkelman, Shibam Ghosh, Nathan Keller, Gaëtan Leurent, Avichai Marmor, and Victor Mollimard. Partial Sums Meet FFT: Improved Attack on 6-Round AES. In *Advances in Cryptology – EUROCRYPT 2024*, pages 128–157. Springer, 2024 ([DOI](#))
3. Anup Kumar Kundu, Shibam Ghosh, Dhiman Saha, and Mostafizar Rahman. Divide and Rule: DiFA - Division Property Based Fault Attacks on PRESENT and GIFT. In *ACNS (1)*, volume 13905 of *Lecture Notes in Computer Science*, pages 89–116. Springer, 2023 ([DOI](#))
4. Orr Dunkelman, Shibam Ghosh, and Eran Lambooj. Full Round Zero-Sum Distinguishers on TinyJAMBU-128 and TinyJAMBU-192 Keyed-Permutation in the Known-Key Setting. In *INDOCRYPT*, volume 13774 of *Lecture Notes in Computer Science*, pages 349–372. Springer, 2022 ([DOI](#))
5. Nilanjan Datta, Avijit Dutta, and Shibam Ghosh. INT-RUP Security of SAEB and TinyJAMBU. In *INDOCRYPT*, volume 13774 of *Lecture Notes in Computer Science*, pages 146–170. Springer, 2022 ([DOI](#))
6. Shibam Ghosh and Orr Dunkelman. Automatic Search for Bit-Based Division Property. In *LATINCRYPT*, volume 12912 of *Lecture Notes in Computer Science*, pages 254–274. Springer, 2021 ([DOI](#))
7. Shibam Ghosh and Léo Perrin. Some Experimental Results on Quadratic APN Functions. In *Boolean Functions and their Applications (BFA) 2021*, 2021 (available online [here](#))

## UNDER SUBMISSION

1. Nilanjan Datta, Avijit Dutta, Shibam Ghosh, and Hrithik Nandi. Optimally secure TBC based accordion mode. *Cryptology ePrint Archive*, Paper 2024/2053, 2024
2. Anup Kumar Kundu, Shibam Ghosh, Aikata Aikata, and Dhiman Saha. ToFA: Towards fault analysis of GIFT and GIFT-like ciphers leveraging truncated impossible differentials. *Cryptology ePrint Archive*, Paper 2024/1927, 2024
3. Automatically Verifying Differential Characteristics and Learning Key Conditions (Major Revision, FSE 2024)
4. Differential Cryptanalysis of the Reduced Pointer Authentication Code Function used in Arm’s FEAT\_PACQARMA3 Feature (Major Revision, FSE 2024)

## Research Talks Delivered

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2024	<b>Partial Sums Meet FFT: Improved Attack on 6-Round AES</b> , Eurocrypt, 2024	Zurich, Switzerland
2023	<b>Attacking the IETF/ISO Standard for Internal Re-keying CTR-ACPKM</b> , FSE, 2023	Kobe, Japan
2022	<b>Full Round Zero-Sum Distinguishers on TinyJAMBU-128 and TinyJAMBU-192</b> , Indocrypt, 2022	Kolkata, India
2021	<b>Automatic Search for Bit-based Division Property</b> , Latincrypt, 2021	Vital
2021	<b>Some Experimental Results on Quadratic APN Functions</b> , BFA, 2021	Vital

## Technical Projects

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### Improved Attack on 6-Round AES



#### PRACTICAL ATTACKS

- I have presented a Fast Fourier Transform-based key-recovery attack on 6-round AES at Eurocrypt 2024.
- The attack is fully implemented in C and verified on Amazon AWS servers.
- The source code is available in my [git](#) and published in IACR [artifact](#).

### Forgery Attacks on NIST Lightweight Crypto Finalist TinyJAMBU



#### PRACTICAL ATTACKS

- I have implemented a practical related-key forgery attack on the TinyJAMBU-v2 with 256/192-bit keys in C.
- Part of this work was published at FSE 2023 and the source code is available in my [git](#).

### Automatic Tools For Algebraic Attacks



#### TOOLS IN CRYPTANALYSIS

- I have prepared Python-based automatic tools for cryptanalysis of NIST lightweight ciphers using MILP, SAT, and CP, available in my [git](#).

### Automatic Tool for Verifying Differential Characteristics



#### TOOLS IN CRYPTANALYSIS

- This project involves developing a tool using publicly available #SAT solvers that thoroughly verifies differential characteristics.
- The tool calculates the expected probability of differential characteristics while considering the cipher's key schedule.
- This tool also estimates the size of the key-space that validates the characteristic and deduces conditions for these keys.
- The paper is being submitted and the tool will appear soon in my [git](#).

## Ongoing Projects

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### Security Analysis of Arm's Pointer Authentication Code (PAC)



#### PRACTICAL ATTACKS

- This project focuses on the Qarma cipher, utilized in the Arm A-profile and M-profile architectures as a Pointer Authentication Code.
- Pointer Authentication is important to mitigate Return-Oriented Programming (ROP) exploits.
- We are preparing an SAT-solver-based automatic tool to search differential properties of Qarma.

### White-Box Secure Cipher



#### PRIMITIVE DESIGN

- We aim to propose an Even-Mansour variant of white-box secure cipher family
- The main objective is to achieve space-hardness and longevity security in specific adversarial environments.

### Embedded Code Encryption

#### PRIMITIVE DESIGN

- We aim to propose a low-latency block cipher intended to support external memory encryption.
- My primary contribution is in the analysis of the block cipher.

## Teaching Experience

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### University of Haifa

Haifa, Israel

#### TEACHING ASSISTANT

2022 – 2024

- Introduction to cryptography, Spring Semester, 2022 (lecturer in charge: Prof. Orr Dunkelman)
- Introduction to cryptography, Spring Semester, 2023 (lecturer in charge: Prof. Orr Dunkelman)
- Introduction to cryptography, Spring Semester, 2024 (lecturer in charge: Prof. Orr Dunkelman)
- Israeli School on Biometrics, 2024 (lecturer in charge: Prof. Orr Dunkelman)

## Other Professional Activities

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### REVIEWER

- Asiacrypt 2024
- Selected Areas in Cryptography (SAC) 2024
- Designs, Codes and Cryptography (DCC) 2024, 2023, 2022


## Awards

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2021	<b>Israeli Science Foundation (ISF) Fellowship</b> , Israeli Science Foundation (ISF)	<i>Haifa, Israel</i>
2020	<b>Data Science Research Center (DSRC) Fellowship</b> , University of Haifa	<i>Haifa, Israel</i>
2020	<b>Awarded departmental-topper prize</b> , Indian Statistical Institute	<i>Kolkata, India</i>
2019	<b>Rank 88 in National Eligibility Test</b> , Council of Scientific and Industrial Research (CSIR), India	<i>Kolkata, India</i>

## Technical Skills

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 C, C++	● ● ● ● ● ●
 python, SageMath	● ● ● ● ● ●
 Rust	● ● ● ● ● ●
 Git	● ● ● ● ● ●
 Qiskit	● ● ● ● ● ●

## Languages

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<b>Native</b>	Bengali
<b>Fluent</b>	English, Hindi