Auld Alliance is back

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Rump session, FSE, 2022

“The Auld Alliance”

THE AULD ALLIANCE IS BACK!

Designing Butterfly-based Hash Functions

Emerging uses in symmetric cryptography

Zero-knowledge proofs $\Rightarrow$ New primitives

designed to minimize the number of multiplications in finite fields.

"Usual" case

- operations on $\mathbb{F}_{2^\eta}$, $\eta \simeq 4, 8$.
- CPU instructions and hardware components

Arithmetization-friendly

- operations on $\mathbb{F}_\rho$, $\rho \in \{2^\eta, \pi\}$, π prime, $\pi \simeq 2^\eta, \eta \geq 64$.
- large finite-field arithmetic

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Design goals:

- Compatibility with Various Proof Systems.
- Limited Reliance on Randomness.
- Different Algorithms for Different Purposes.
- Design Consistency.

CCZ-equivalence

Definition

$\phi : \mathbb{F}_\rho \to \mathbb{F}_\rho$ and $\psi : \mathbb{F}_\rho \to \mathbb{F}_\rho$ are **CCZ-equivalent**

$$\Gamma_\phi = \left\{ (\chi, \phi(\chi)) \mid \chi \in \mathbb{F}_\rho \right\} = \theta(\Gamma_\psi) = \left\{ \theta(\chi, \phi(\chi)) \mid \chi \in \mathbb{F}_\rho \right\},$$

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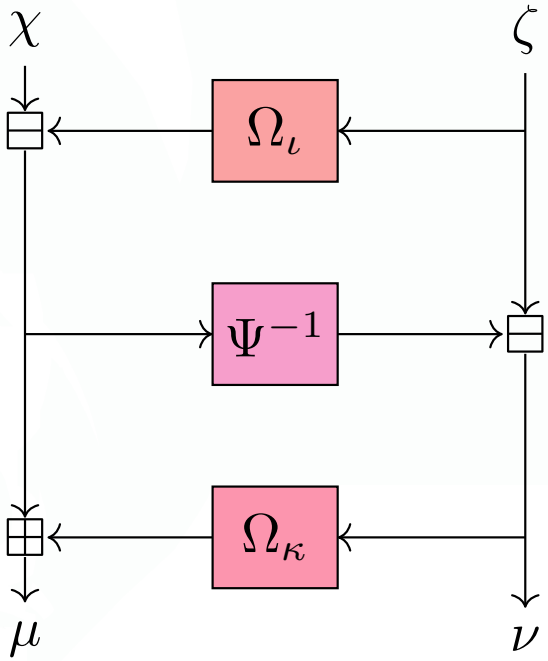
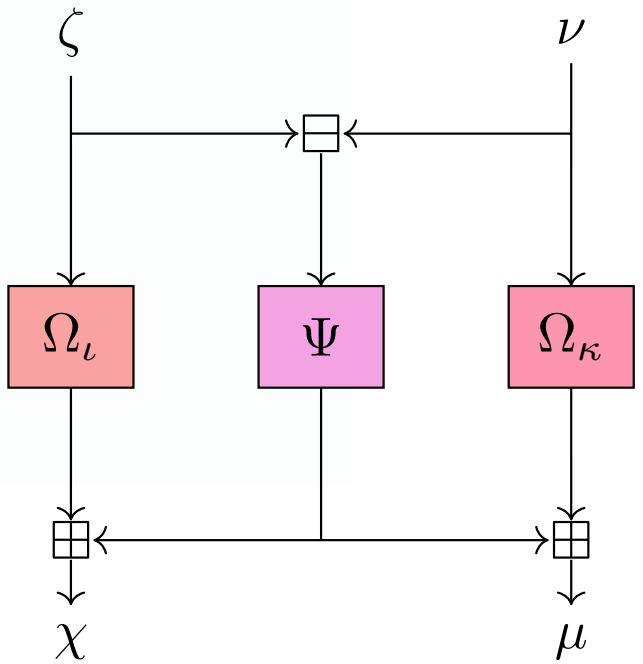


Open `Flystel`.



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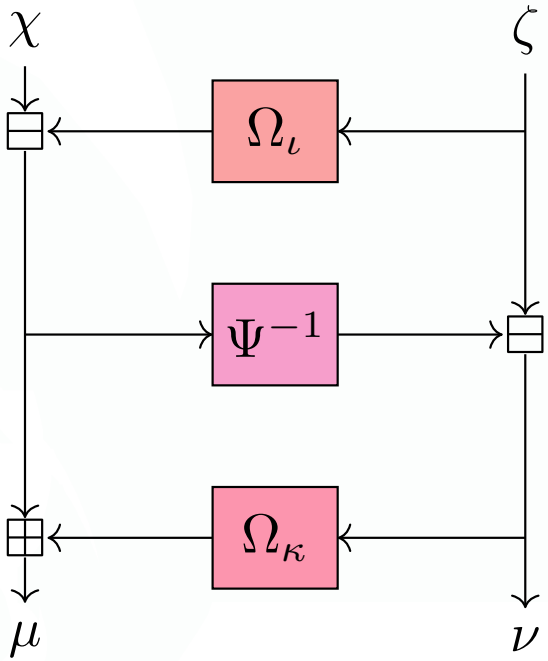
CCZ-equivalence

- High Degree.
- Low Differential Uniformity.
- Low Cost Verification.
- Less Costly Evaluation.



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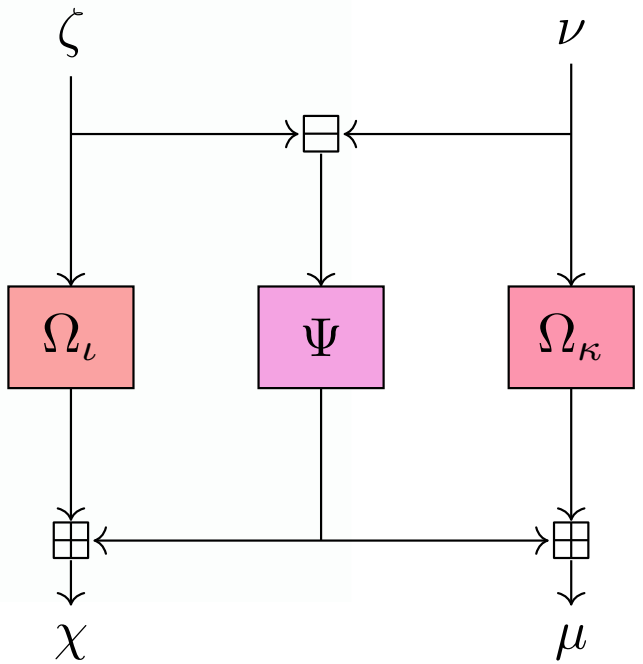

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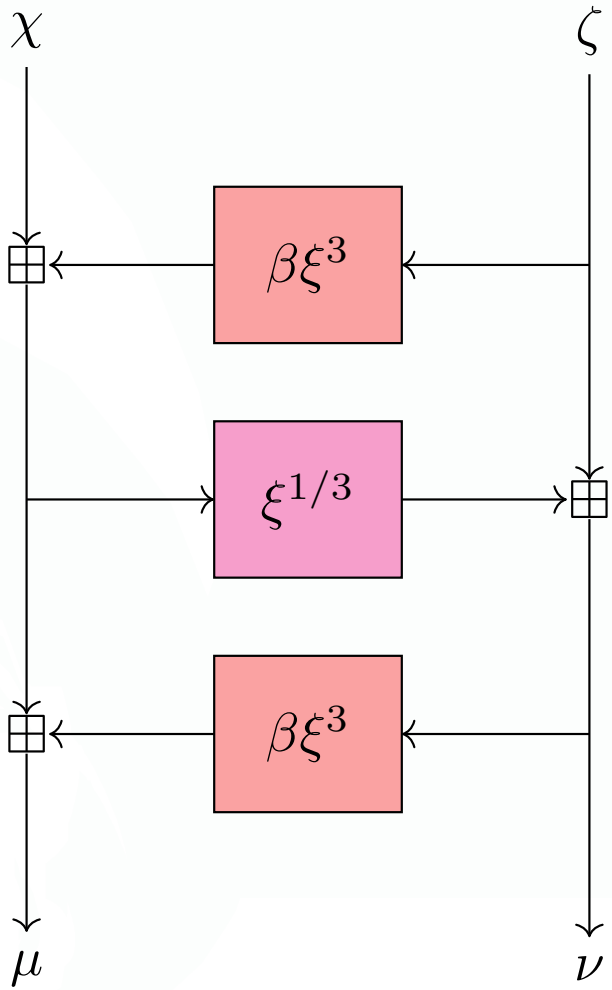
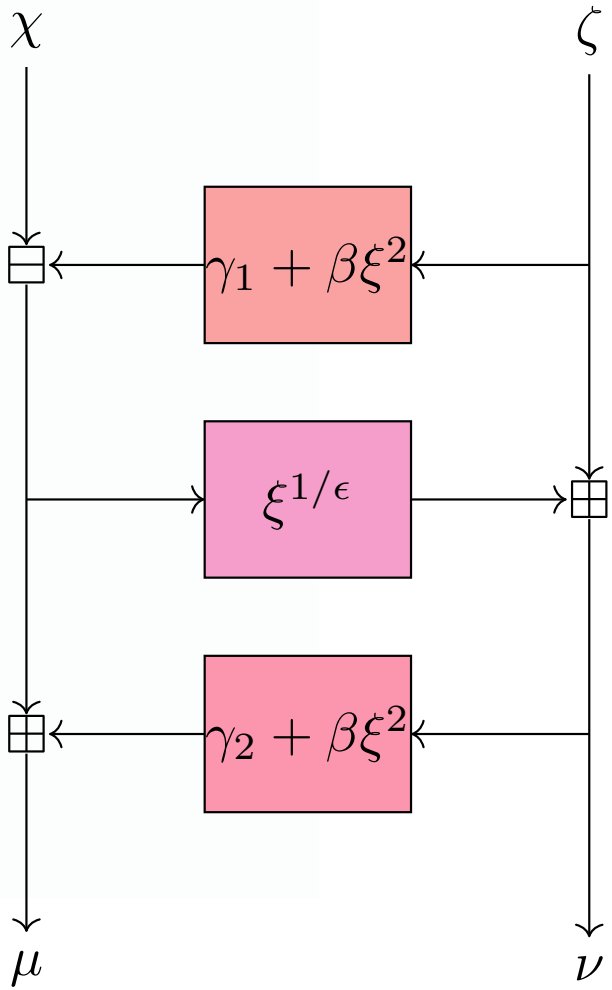


Flystel in $\mathbb{F}_{2^\eta}$.



Flystel in $\mathbb{F}_\pi$.

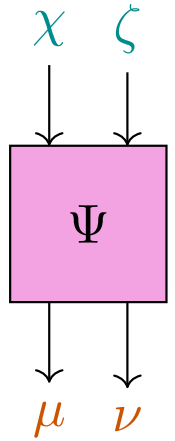
New Mode

- Random oracle replacement: `AuldRO`
- Collision resistant compression function for Merkle-trees: `AuldMC`

Dedicated mode

$$\Pi_\iota : (\chi, \zeta) \mapsto \Lambda \circ \phi(\chi + \kappa_\iota, \zeta + \omega_\iota) \ ,$$

$$(\mu, \nu) = (\Pi_{\eta-1} \circ \ldots \circ \Pi_0)(\chi, \zeta) \ ,$$



$\Rightarrow$ 2 words in 1

$$(\chi, \zeta) \mapsto \chi + \zeta + \mu + \nu \ .$$

The Conquest of Athens

Athena and Poseidon