Rate-Splitting Multiple Access for Enhanced RIS and Integrated Sensing and Communication Systems: A Survey

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***Abstract*—The increasing demands of future 6G networks, characterized by ultra-high data rates, ubiquitous connectivity, and diverse service requirements, necessitate a fundamental re-evaluation of current wireless communication paradigms. This survey provides an in-depth analysis of two pivotal technologies poised to address these challenges: Reconfigurable Intelligent Surfaces (RIS) and Integrated Sensing and Communication (ISAC), both empowered by the robust interference management capabilities of Rate-Splitting Multiple Access (RSMA). We split the paper into the foundational principles of RSMA, RIS, and ISAC, followed by dedicated sections on RSMA-RIS and RSMA-ISAC systems. A comparative analysis highlights their distinct advantages and the role of RSMA in each. Finally, we identify crucial open research directions, including the area of combined RSMA-RIS-ISAC systems, to guide future innovations in 6G.**

***Index Terms*—RSMA, RIS, ISAC, 6G, Interference Management.**

I. Introduction

The relentless proliferation of mobile devices, bandwidth-intensive applications, and the push for an interconnected world are driving explosive data growth and demand for ubiquitous, high-performance connectivity. Future 6G networks aim to deliver enhanced mobile broadband and support holographic communication, extended reality (XR), and advanced intelligent sensing [1]. This vision is constrained by limits of current wireless technologies: traditional multiple access (MA) schemes such as SDMA and NOMA struggle with interference in dense, dynamic environments [2], and precise control of the radio environment remains elusive.

Two enablers have emerged: Rate-Splitting Multiple Access (RSMA) and Reconfigurable Intelligent Surfaces (RIS), alongside the rising paradigm of Integrated Sensing and Communication (ISAC) [3], [4]. RSMA, a general interference-management framework, improves robustness by splitting user messages into common and private streams [3]. RIS promises "smart" environments via programmable reflection/refraction [5]. ISAC co-designs sensing and communication to boost spectral and hardware efficiency, enabling applications in vehicular networks, smart cities, and IoT [4], [6].

Integrating RSMA with RIS and ISAC is a natural evolution: RSMA-RIS jointly designs BS precoders and RIS phase shifts to shape channels and mitigate interference [7], while RSMA-ISAC manages both inter-user and sensing–communication interference to balance dual objectives [3], [4]. This paper surveys the state of the art in RSMA-RIS and RSMA-ISAC, outlines fundamentals, compares their challenges and opportunities, and identifies open directions—including the promising RSMA-RIS-ISAC triad—to guide future research.

II. Fundamentals of Key Technologies

A. RSMA

RSMA is a generalized and robust multiple access scheme that offers superior interference management capabilities compared to traditional approaches like SDMA and NOMA [3]. The core concept of RSMA revolves around splitting messages intended for users into common and private parts. In a typical downlink scenario, a message for a user is partially encoded into a common stream that is decoded by a subset of users, and the remaining part is encoded into a private stream intended only for that specific user. Successive Interference Cancellation (SIC) is then employed at the receivers to decode these streams [3].

The most common structure is 1-layer RSMA, where a common stream is decoded by all users, and each user also receives a private stream. More advanced 2-layer RSMA involves multiple common streams decoded by different subsets of users, offering even greater flexibility in interference management. RSMA inherently subsumes and outperforms many existing MA schemes; it unifies and generalizes SDMA, NOMA, and multicasting by offering a more flexible framework for interference handling [3]. This flexibility allows RSMA to control interference at various levels, leading to improved spectral efficiency, enhanced user fairness, and greater robustness to imperfect Channel State Information (CSI) [8]. For instance, RSMA has been shown to mitigate the curse of mobility in massive MIMO networks [4].

B. RIS

RIS, also known as an Intelligent Reflecting Surface (IRS), is a planar array composed of numerous passive or active reflecting elements, each capable of independently adjusting the phase shift of incident electromagnetic waves [5]. Unlike traditional relays that amplify and forward signals, an RIS simply reflects or refracts signals, without requiring complex signal processing or dedicated energy harvesting at the surface itself [9].

The physical structure of an RIS typically consists of a large number of low-cost, passive metallic or dielectric elements embedded with PIN diodes or varactor diodes, which can be controlled by a centralized controller. By adjusting the phase shifts of these elements, the RIS can effectively reshape the wireless propagation environment, creating constructive interference at desired receivers and destructive interference at undesired ones. This manipulation allows for the dynamic reconfigurability of wireless channels, enabling enhanced coverage, reduced interference, and improved energy efficiency [5].

C. ISAC

ISAC, often referred to as Dual-Functional Radar-Communication (DFRC), is a promising paradigm for future wireless networks that aims to achieve both sensing and communication functionalities using shared hardware and spectral resources [3]. The primary motivation behind ISAC is to improve spectral efficiency and reduce hardware complexity by allowing a single platform, such as a base station or a dedicated ISAC device, to simultaneously communicate with users and sense objects in the environment, like moving targets or obstacles [1], [4].

The performance of an ISAC system is evaluated based on metrics for both communication and sensing. For communication, key metrics include data rate, spectral efficiency, energy efficiency, and outage probability [6], [10]. For sensing, metrics typically include the Cramér-Rao Bound (CRB) for target parameter estimation (e.g., distance, angle, velocity), detection probability, and radar signal-to-interference-plus-noise ratio (SINR) [3], [11]. The fundamental challenge in ISAC system design is to manage the inherent trade-off between these often-conflicting communication and sensing objectives, as optimizing one might degrade the other [4], [12].

III. A Deep Dive into RSMA-RIS

A. Motivation

The primary motivation to combine RSMA and RIS stems from the unique properties of each technology. RIS introduces a massive number of virtual channel links and offers unprecedented control over the wireless propagation environment, but this also inherently increases the complexity of managing interference [13]. RSMA, with its robust and flexible interference management framework, becomes even more critical in such RIS-assisted scenarios. It can effectively handle the interference arising from multiple users and the complex reflected paths introduced by the RIS, thereby maximizing the gains provided by the RIS [7], [14]. For instance, in RIS-aided cell-edge user scenarios, RSMA can significantly improve outage probability by carefully managing inter-user interference [2].

B. System Model

A typical RSMA-RIS system often involves a multi-antenna base station (BS) communicating with multiple single-antenna or multi-antenna users. An RIS, comprising numerous passive reflecting elements, is strategically deployed in the environment to assist communication, often by establishing a virtual line-of-sight (LoS) link or by bypassing blockages [7], [15]. The BS employs RSMA by splitting messages into common and private streams, which are then encoded and transmitted. The RIS then reflects these signals with carefully designed phase shifts to enhance the desired signal paths and suppress interference at the user receivers. The system model for an RIS-aided uplink millimeter-wave (mmWave) system with RSMA has also been investigated for sum-rate maximization [14].

C. Categorization of Literature

- **Optimization Objectives:** Research in RSMA-RIS systems often focuses on various optimization goals to enhance system performance. These include sum-rate maximization [14], energy efficiency maximization [10], [16], and max-min fairness among users [16]. Papers also investigate secrecy rate maximization for secure communication, leveraging RSMA's ability to create artificial noise for eavesdroppers [16], [17]. For instance, in RIS-assisted SWIPT (Simultaneous Wireless Information and Power Transfer) networks, the joint optimization of beamforming, power splitting, common message rates, and discrete phase shifts aims to maximize energy efficiency [10].
- **Hardware Constraints:** Practical deployments necessitate considering hardware limitations. Several works explore systems with discrete phase shifts at the RIS elements, moving beyond the ideal continuous phase shift assumption [2]. The impact of low-resolution quantization digital-to-analog converters (DACs) at the transmitter has been studied in RSMA-ISAC LEO satellite systems for energy efficiency, though this can also apply to RSMA-RIS systems [18]. Additionally, the emerging concept of active RIS, which amplifies signals during reflection, has been considered in conjunction with RSMA for secure ISAC systems [9].
- **CSI:** The availability and accuracy of CSI are critical. Research often distinguishes between perfect CSI, where all channel information is perfectly known, and imperfect CSI, which accounts for estimation errors or outdated information [7], [14]. Techniques for CSI acquisition and robust design against CSI uncertainties are crucial for practical RSMA-RIS implementations.

D. Key Design Challenges

The primary design challenge in RSMA-RIS systems lies in the joint optimization of the active beamforming vectors at the BS and the passive phase shifts at the RIS [7], [19]. This joint problem is typically highly non-convex, involving both continuous and discrete variables (for discrete phase shifts)

[2]. Iterative algorithms, often based on successive convex approximation (SCA), semidefinite relaxation (SDR), penalty methods, or weighted minimum mean square error (WMMSE) approaches, are commonly proposed to tackle these complex optimization problems [7], [17], [19]. Efficient algorithms are crucial to achieving significant performance gains while managing computational complexity.

IV. A Deep Dive into RSMA-ISAC

A. Motivation

The motivation for employing RSMA in ISAC systems is multifaceted. ISAC systems inherently involve a trade-off between communication and sensing performance, as the resources (e.g., power, spectrum, antennas) are shared between these two functionalities [4], [12]. Furthermore, multi-user interference from communication users can degrade sensing performance, and conversely, sensing signals can cause interference to communication users. RSMA provides a flexible and robust framework for managing both multi-user interference within the communication component and the mutual interference between the communication and sensing functionalities [3], [4]. By strategically splitting messages, RSMA can effectively control interference at the receivers while simultaneously leveraging the common stream as a part of the sensing waveform, thereby achieving a more favorable communication-sensing trade-off compared to conventional approaches [3], [11].

B. System Model

A typical RSMA-ISAC system usually features a dual-functional base station (BS) equipped with multiple antennas. This BS is designed to simultaneously communicate with multiple downlink users and probe detection signals towards specific azimuth angles of interest or to sense a moving target [3], [4]. The communication messages are split into common and private streams via RSMA, and these streams, along with a dedicated radar sequence if it has used, are jointly precoded and transmitted. The sensing function then utilizes the reflected signals from the target to estimate parameters like its distance, angle, and velocity [11]. Such systems have been explored in various scenarios, including device-to-multi-device IoT communications [6], cooperative ISAC systems with direct localization [12], and near-field integrated sensing [11].

C. Categorization of Literature

- **Performance Trade-offs:** A significant portion of research in RSMA-ISAC focuses on analyzing and optimizing the fundamental trade-off between communication and sensing performance. This often involves formulating optimization problems that aim to maximize a communication metric (e.g., sum rate, minimum fairness rate, secrecy rate) while satisfying sensing constraints (e.g., minimum radar SINR, maximum CRB), or vice versa [4], [12], [18], [20]. Studies demonstrate that RSMA provides a better communication-sensing trade-off than conventional benchmark strategies like SDMA [4]. Cooperative ISAC systems, for example, use a Pareto optimization framework to characterize the achievable performance region between communication sum rate and positioning error bound [12].
- **Waveform Design:** RSMA's message splitting paradigm also influences waveform design in ISAC. The common and private streams can be designed to serve not only communication purposes but also to contribute effectively to the sensing functionality [3], [11]. This involves jointly optimizing the message splits, communication precoders, and radar sequences to achieve desired communication rates and radar beampatterns or estimation accuracy [3], [11]. In near-field ISAC, the preconfigured communication beams can be sufficient for target sensing, eliminating the need for additional probing signals [11].
- **System Architectures:** RSMA-ISAC has been investigated across diverse system architectures. This includes multi-antenna DFRC systems where the BS has dual capability [3], cooperative ISAC (CoISAC) with multiple base stations [12], device-to-multi-device IoT communications facilitated by a cooperative access point [6], and even low earth orbit (LEO) satellite systems with sensing functionality [18]. UAV-based ISAC systems could also benefit from RSMA's interference management capabilities.

D. Key Design Challenges

The core design challenges in RSMA-ISAC systems stem from the inherent conflict between communication and sensing objectives and the complexity of joint optimization. Defining a unified performance metric that effectively balances these conflicting goals is a non-trivial task. Furthermore, designing the waveforms and precoders that achieve a favorable balance is a highly complex non-convex optimization problem [3], [11]. Robustness against imperfect CSI is also a crucial consideration for practical ISAC deployments [9]. Iterative algorithms, often leveraging techniques like Alternating Direction Method of Multipliers (ADMM), successive convex approximation (SCA), semidefinite relaxation (SDR), and quadratic transform, are employed to solve these intricate problems [3], [11], [12]. Security is another significant concern due to shared spectrum and broadcast nature, where RSMA can enhance physical layer security against eavesdroppers [20].

V. Future Research Directions and Open Challenges

While both RSMA-RIS and RSMA-ISAC are emerging 6G technologies, they address distinct challenges and leverage RSMA in unique ways. Table I highlights their primary objectives, technical underpinnings, and design considerations. Besides that, Table II summarizes representative RSMA-RIS and RSMA-ISAC research works. The table highlights the system scenarios considered, the main objectives addressed, the performance metrics evaluated, and the key features or challenges of each study. This comparison offers a concise reference point for understanding how RSMA has been applied in

TABLE I: RSMA-RIS and RSMA-ISAC analysis

Feature	RSMA-RIS	RSMA-ISAC
Primary goal	Communication enhancement (rate, energy efficiency, coverage, security)	Dual functionality: Simultaneous communication and sensing
Key Technology Leveraged	Environment control (RIS for channel manipulation)	Signal processing (ISAC for shared resource utilization)
Main Design Problem	Joint beamforming (BS) and passive/active phase shift optimization (RIS)	Communication-sensing trade-off optimization; joint waveform and precoder design
Role of RSMA	Managing multi-user interference in an artificially controlled channel	Managing both inter-user communication interference and inter-function (comm-sensing) interference
System Components	Base Station, Communication Users, Reconfigurable Intelligent Surface	Dual-functional Base Station, Communication Users, Sensing Targets
Interference Type	Primarily multi-user interference, augmented by RIS reflection paths	Multi-user interference and mutual interference between communication and sensing signals

RIS-assisted communication systems and ISAC architectures, and how these works collectively inform future 6G design directions.

A. RSMA-RIS

- **Machine Learning for Optimization:** The joint optimization problems inherent in RSMA-RIS are highly complex and frequently non-convex. To address these challenges, deep reinforcement learning (DRL) and other machine learning (ML) techniques present promising solutions. DRL, in particular, has demonstrated strong performance across various wireless communication domains, including unmanned aerial vehicle (UAV) communications, adaptive video streaming, and underwater networks [21]–[23]. Similarly, other ML approaches, such as the PPO-based method explored for maximizing energy efficiency, can facilitate intelligent and adaptive resource allocation, especially in dynamic environments where traditional optimization methods may falter [10].
- **Practical Channel Estimation:** Accurate CSI is crucial for optimal performance, but acquiring CSI for RIS-assisted systems, particularly with a massive number of elements, is a significant challenge. Future work should focus on low-overhead and robust CSI acquisition techniques, including sparse channel estimation and machine learning-aided prediction. The impact of imperfect CSI on RSMA-RIS performance requires further investigation [14].
- **Mobility Support:** Most current research assumes static or slow-moving scenarios. Developing RSMA-RIS solutions for highly mobile users and RIS-enabled vehicular environments, such as those involving UAVs as aerial RISs, will be critical for practical deployment [15]. This requires addressing dynamic channel variations and handover mechanisms.
- **Integration with Other Technologies:** Exploring the synergistic integration of RSMA-RIS with other emerging 6G technologies, such as Orthogonal Frequency Division Multiplexing (OFDM) for multi-carrier systems, NOMA for specific scenarios (e.g., in VLC systems where RSMA and NOMA are compared [16]), and terahertz (THz) communications, could unlock new performance frontiers.
- **Active and STAR RIS:** While passive RISs are energy-efficient, active RISs can amplify signals, potentially overcoming the multiplicative fading issue. Further research is needed on the optimal deployment and resource allocation for active RISs within RSMA frameworks, especially concerning power consumption and interference generation [9]. Similarly, STAR (Simultaneous Transmitting and Reflecting) RISs, which can serve users on both sides, open up new dimensions for coverage and interference management with RSMA [24].

B. RSMA-ISAC

- **Security Aspects:** Due to the shared spectrum and broadcast nature of ISAC signals, security becomes a paramount concern. Malicious targets or eavesdroppers can exploit radar signals for information leakage. RSMA has shown promise in enhancing physical layer security by acting as artificial noise [17], [20]. Further research is needed on robust secure beamforming designs against intelligent eavesdroppers and in the presence of imperfect CSI for ISAC systems.
- **Impact of Cluttered Environments:** Current ISAC research often considers simplified propagation models. Investigating the performance of RSMA-ISAC in complex, cluttered environments (e.g., urban areas, indoor settings) where multipath fading and non-line-of-sight (NLoS) components are dominant, and how these affect sensing accuracy, is essential.
- **Multi-Base Station Coordination:** Coordinating multiple ISAC-enabled BSs could significantly enhance both communication and sensing performance through macro-diversity and distributed sensing. Research into joint RSMA precoding and sensing signal design across multiple coordinated BSs for coherent sensing and communication is an important future direction [12].
- **Experimental Validation:** Most of the existing literature is based on theoretical analysis and simulations. Experimental validation and prototyping of RSMA-ISAC systems are crucial to demonstrate their practical feasibility and to identify real-world challenges not captured by simulations.
- **Specific Sensing Applications:** Tailoring RSMA-ISAC designs for specific sensing applications, such as high-

TABLE II: Key RSMA-RIS and RSMA-ISAC Studies – Systems, Objectives, and Metrics

Category	Doc.	System Scenario / Architecture	Main Objective / Approach	Key Metrics	Key Features / Challenges
RSMA-RIS	[10]	MISO system with multi-antenna BS, K cell-edge users, each aided by a dedicated RIS.	Investigate Outage Probability (OP) considering discrete and optimal RIS phase-shifts.	Outage Probability (OP)	Discrete phase-shifts; cell-edge users; interdependent constraints of threshold and RSMA factors.
	[12]	RIS-assisted Simultaneous Wireless Information and Power Transfer (SWIPT) networks.	Maximize Energy Efficiency (EE) by jointly optimizing beamforming, power splitting, common rates, and discrete phase shifts using PPO.	Energy Efficiency (EE), QoS for information	Deep Reinforcement Learning (PPO); non-convex problem with discrete/continuous variables; SWIPT.
	[13]	Multiple RISs-aided Uplink (UL) millimeter-wave (mmWave) system with multi-user scenario.	Sum-rate maximization via joint optimization of UL power allocation and beamforming (active at BS, passive at RISs). Uses k-means user clustering and alternating optimization.	Sum-rate	High inter-node interference; mmWave; dynamic user clustering; uplink.
	[19]	STAR (Simultaneous Transmitting and Reflecting) RIS-aided RSMA communication. BS serves users on both sides of STAR-RIS.	Analyze performance (OP, capacity, BLER, goodput) over spatially-correlated Rician channels with ES/MS configurations.	OP, Channel Capacity, Block Error Rate (BLER), System Goodput	STAR-RIS (Energy Splitting/Mode Switching); spatially-correlated channels; finite/infinite block-length.
RSMA-ISAC	[1]	Multi-antenna Dual-Functional Radar-Communication (DFRC) system. BS performs downlink communication and probes radar detection signals.	Design message splits and precoders (common, private, radar sequence) to jointly achieve communication and radar goals.	Communication Performance (implicit), Radar Beampattern, Target Detection	Joint design of communication and radar streams; interference management between functions.
	[2]	General RSMA-assisted ISAC architecture (BS communicates with users and senses a moving target).	Tutorial on interplay, with design example to jointly minimize Sensing Cramér–Rao Bound (CRB) and maximize Communication Minimum Fairness Rate (MFR).	Sensing CRB (target estimation), Communication MFR	Fundamental communication–sensing trade-off; 6G context; terrestrial/satellite scenarios.
	[3]	Cooperative ISAC (CoISAC) system with multiple BSs and direct localization for sensing.	Pareto optimization framework to characterize achievable performance region between communication sum rate and sensing positioning error bound.	Communication Sum Rate, Sensing Positioning Error Bound	Cooperative ISAC; direct localization; Pareto optimization; iterative algorithms (SCA) for non-convex problems.
	[8]	ISAC system with potential eavesdroppers.	Enhance Physical Layer Security (PLS) by jointly optimizing precoding matrix and common rate to maximize weighted Secure Sum Rate (SSR).	Weighted Secure Sum Rate (SSR), Physical Layer Security (PLS)	Physical layer security; eavesdropping; non-convex optimization (SCA-P); shared spectrum vulnerability.

resolution imaging, gesture recognition, or vital sign detection, will require specialized waveform and precoder designs, along with appropriate performance metrics.

C. Combination of RIS and ISAC with RSMA

The most cutting-edge research direction involves the synergistic combination of all three technologies: RSMA-RIS-ISAC. This entails using an RIS to assist a dual-functional RSMA system that simultaneously performs communication and sensing [7], [19].

- **Benefits:** An RIS could actively reshape the propagation environment for an ISAC system, potentially overcoming blockages, extending sensing range, enhancing communication coverage, and reducing interference for both functionalities. RSMA's interference management would then become even more powerful in this highly controllable environment. For instance, an RIS could create a virtual line-of-sight link for a sensing target or communication user, improving signal strength and reducing the Cramér-Rao Bound [19]. An active RIS could even amplify sensing returns or steer communication signals more effectively in an ISAC context [9].
- **Challenges:** The complexity of joint optimization would be significantly higher, involving the integrated design of BS precoders, RIS phase shifts, and ISAC waveforms for both communication and sensing objectives. Defining the optimal trade-offs and performance metrics for such a tri-functional system is a major challenge. The signaling overhead for CSI acquisition (for both communication users, sensing targets, and the RIS) would also be substantial. Furthermore, addressing the potential interference generated by the RIS itself, especially an active RIS, within an ISAC framework requires careful consideration.
- **Future Direction:** Future research should focus on DRL-enabled wireless edge learning, where continuous-control methods like DDPG deliver energy-efficient resource allocation. This DDPG framework serves as a template for the joint design of precoding, RIS tuning, and sensing waveforms in RSMA-ISAC systems [25]. At the MAC

layer, asynchronous duty-cycling and queue-aware controls, such as DACODE, provide a model for reducing power while maintaining stability in dense RSMA-RIS-ISAC IoT deployments [26]. These techniques motivate a learning-driven, cross-layer RSMA-RIS-ISAC design that merges DDPG-style joint control of RSMA message splitting, RIS phases, and sensing with DACODE-like queueing and duty-cycling to prioritize sensing-critical streams and reduce control overhead in dynamic environments.

VI. Conclusion

The shift to 6G networks requires new wireless designs to deliver higher data rates and intelligent services. This survey highlights RIS and ISAC as key technologies, both significantly enhanced by the superior interference management of RSMA. RSMA offers a flexible framework that surpasses traditional access schemes, improving spectral efficiency and coverage in RSMA-RIS systems while balancing the communication-sensing trade-off in RSMA-ISAC systems. A promising research direction is the integration of all three technologies into a unified RSMA-RIS-ISAC system, paving the way for intelligent networks where communication and sensing seamlessly converge.

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References

[1] X. Zhu, J. Liu, L. Lu, T. Zhang, T. Qiu, C. Wang, and Y. Liu, "Enabling intelligent connectivity: A survey of secure isac in 6g networks," *IEEE Communications Surveys Tutorials*, vol. 27, no. 2, pp. 748–781, 2025.

[2] D. Shambharkar, S. Dhok, A. Singh, and P. K. Sharma, "Rate-splitting multiple access for ris-aided cell-edge users with discrete phase-shifts," *IEEE Communications Letters*, vol. 26, no. 11, pp. 2581–2585, 2022.

[3] C. Xu, B. Clerckx, S. Chen, Y. Mao, and J. Zhang, "Rate-splitting multiple access for multi-antenna joint radar and communications," *IEEE Journal of Selected Topics in Signal Processing*, vol. 15, no. 6, pp. 1332–1347, 2021.

[4] L. Yin, Y. Mao, O. Dizdar, and B. Clerckx, "Rate-splitting multiple access for 6g—part ii: Interplay with integrated sensing and communications," *IEEE Communications Letters*, vol. 26, no. 10, pp. 2237–2241, 2022.

[5] Y. Liu, X. Liu, X. Mu, T. Hou, J. Xu, M. Di Renzo, and N. Al-Dhahir, "Reconfigurable intelligent surfaces: Principles and opportunities," *IEEE Communications Surveys Tutorials*, vol. 23, no. 3, pp. 1546–1577, 2021.

[6] S. Ghosh, K. Singh, H. Jung, C.-P. Li, and T. Q. Duong, "On the performance of rate splitting multiple access for isac in device-to-multi-device iot communications," *IEEE Transactions on Cognitive Communications and Networking*, vol. 11, no. 1, pp. 333–348, 2025.

[7] H. Ke, J. Xu, W. Xu, C. Ding, and D. W. K. Ng, "Rate splitting and beamforming design for ris-assisted rsma-enhanced isac networks," *IEEE Wireless Communications Letters*, vol. 14, no. 6, pp. 1738–1742, 2025.

[8] M. Can, M. C. Ilter, I. Altunbas, and M. Valkama, "Data-oriented uplink rsma systems: Performance analysis and design insight," *IEEE Transactions on Communications*, vol. 73, no. 8, pp. 6639–6654, 2025.

[9] H. Peng, C. He, Z. Zhang, C. Han, and L. Wang, "Robust secure beamforming for integrated sensing and communication systems with the active ris," *IEEE Transactions on Vehicular Technology*, vol. 74, no. 3, pp. 5158–5163, 2025.

[10] R. Zhang, K. Xiong, Y. Lu, P. Fan, D. W. K. Ng, and K. B. Letaief, "Energy efficiency maximization in ris-assisted swipt networks with rsma: A ppo-based approach," *IEEE Journal on Selected Areas in Communications*, vol. 41, no. 5, pp. 1413–1430, 2023.

[11] J. Zhou, C. Zhou, C. Zeng, and C. Tellambura, "Flexible rate-splitting multiple access for near-field integrated sensing and communications," *IEEE Transactions on Vehicular Technology*, vol. 74, no. 7, pp. 11 524–11 528, 2025.

[12] P. Gao, L. Lian, and J. Yu, "Cooperative isac with direct localization and rate-splitting multiple access communication: A pareto optimization framework," *IEEE Journal on Selected Areas in Communications*, vol. 41, no. 5, pp. 1496–1515, 2023.

[13] H. Li, Y. Mao, O. Dizdar, and B. Clerckx, "Rate-splitting multiple access for 6g—part iii: Interplay with reconfigurable intelligent surfaces," *IEEE Communications Letters*, vol. 26, no. 10, pp. 2242–2246, 2022.

[14] M. Katwe, K. Singh, B. Clerckx, and C.-P. Li, "Rate-splitting multiple access and dynamic user clustering for sum-rate maximization in multiple riss-aided uplink mmwave system," *IEEE Transactions on Communications*, vol. 70, no. 11, pp. 7365–7383, 2022.

[15] A. Bansal, N. Agrawal, and K. Singh, "Rate-splitting multiple access for uav-based ris-enabled interference-limited vehicular communication system," *IEEE Transactions on Intelligent Vehicles*, vol. 8, no. 1, pp. 936–948, 2023.

[16] O. Maraqa, S. Aboagye, M. H. Khoshafa, and T. M. N. Ngatched, "Max–min secrecy rate and secrecy energy efficiency optimization for ris-aided vlc systems: Rsma versus noma," *IEEE Open Journal of Vehicular Technology*, vol. 6, pp. 1303–1316, 2025.

[17] C. Zhang, S. Qu, L. Zhao, Z. Wei, Q. Shi, and Y. Liu, "Robust secure beamforming design for downlink ris-isac systems enhanced by rsma," *IEEE Wireless Communications Letters*, vol. 14, no. 5, pp. 1271–1275, 2025.

[18] Z. Liu, L. Yin, W. Shin, and B. Clerckx, "Rate-splitting multiple access for quantized isac leo satellite systems: A max-min fair energy-efficient beam design," *IEEE Transactions on Wireless Communications*, vol. 23, no. 10, pp. 15 394–15 408, 2024.

[19] Z. Chen, J. Wang, Z. Tian, M. Wang, Y. Jia, and T. Q. S. Quek, "Joint rate splitting and beamforming design for rsma-ris-assisted isac system," *IEEE Wireless Communications Letters*, vol. 13, no. 1, pp. 173–177, 2024.

[20] B. Zhao, T. Qiu, G. Ren, Z. Jin, and Z. Liu, "Rsma-enhanced physical layer security for isac systems," *IEEE Wireless Communications Letters*, vol. 14, no. 4, pp. 1064–1068, 2025.

[21] W. J. Yun, S. Park, J. Kim, M. Shin, S. Jung, D. A. Mohaisen, and J.-H. Kim, "Cooperative multiagent deep reinforcement learning for reliable surveillance via autonomous multi-uav control," *IEEE Transactions on Industrial Informatics*, vol. 18, no. 10, pp. 7086–7096, 2022.

[22] W. J. Yun, D. Kwon, M. Choi, J. Kim, G. Caire, and A. F. Molisch, "Quality-aware deep reinforcement learning for streaming in infrastructure-assisted connected vehicles," *IEEE Transactions on Vehicular Technology*, vol. 71, no. 2, pp. 2002–2017, 2022.

[23] D. Kwon, J. Jeon, S. Park, J. Kim, and S. Cho, "Multiagent ddpg-based deep learning for smart ocean federated learning iot networks," *IEEE Internet of Things Journal*, vol. 7, no. 10, pp. 9895–9903, 2020.

[24] S. Dhok and P. K. Sharma, "Rate-splitting multiple access with star ris over spatially-correlated channels," *IEEE Transactions on Communications*, vol. 70, no. 10, pp. 6410–6424, 2022.

[25] M. C. Ho, A. T. Tran, D. Lee, J. Paek, W. Noh, and S. Cho, "A ddpg-based energy efficient federated learning algorithm with swipt and mc-noma," *ICT Express*, vol. 10, no. 3, pp. 600–607, 2024. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2405959523001534

[26] J. Oh, D. Lee, D. S. Lakew, and S. Cho, "Dacode: Distributed adaptive communication framework for energy efficient industrial iot-based heterogeneous wsn," *ICT Express*, vol. 9, no. 6, pp. 1085–1094, 2023. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2405959523000267