Improved Spatially Coupled Multiuser Transmission via Constellation Rotation

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***Abstract*—In this paper, we apply constellation rotation in spatially coupled multiuser transmission, where each data stream is modulated with constellation rotation, the coupling data is the linearly superposition of certain data streams with time offsets and iterative detecting and decoding is performed. We also seek out the optimal rotation angle set using the mutual information. Simulation results show that constellation rotation contributes to improve the system performance and reduce the complexity of the system. The system with the optimal rotation angle set performs significantly better than the others.**

I. Introduction

With the growing demand of mobile communication, the fifth generation(5G) wireless communication faces many challenges including high spectral efficiency and massive connection. Therefore, conventional orthogonal multiple access(OMA) is inadequate to meet the demand and non-orthogonal multiple access(NOMA)[1] catches numerous attractions for its resource allocation in time/frequnecy domain. In NOMA, data streams from different users are allowed to be superimposed which makes the system achieve higher spectral efficiency. NOMA modulation[2], power allocation and user scheduling[3] are potential research directions to improve system performance.

Spatial graph coupling is a method where a new graph is produced by connecting copies of a single graph with certain rules. The technique was first applied to construct conventional low-density parity-check(LDPC) codes[4] which proved to reach similar threshold to the maximum a posteriori probability(MAP) decoding threshold of corresponding LDPC block codes[5]. Recently, some applications of the method have been found in multiple access, where different users share the same resource block by superimposing different data streams with time offsets. In [6], it has been proved that the spatial coupling with enough width achieves the capacity of random multiple access channel. Spatial coupling is used in code-division multiple-access(CDMA) in [7] which improves the performance of iterative multiuser detection. [8] proposes a multiple access demodulation with lower complexity which obtains the same performance as the others.

Spatially coupled transmission achieves a good performance in terms of high utilization in theory, but actually, the interference between different data streams of all users is difficult to distinguish with the help of channel coding. To solve this problem, constellation rotation is introduced. Constellation rotation contributes to increase the modulation diversity and is widely used to make further distinction when data is superimposed. [9] combines constellation rotation with symbol mapping which increases the spectral efficiency. The multi-dimensional SCMA codebook design with constellation rotation proposed in [10] achieves better performance.

In this paper, we focus on applying constellation rotation in spatially coupled multiuser transmission. Each data stream is equal-power and independent, encoded by LDPC codes[11] and transmitted via AWGN channel. During the modulation, different data streams of each user or all data streams of all users are modulated with constellation rotation. The spatial coupling is constructed by superimposing the data streams with time offsets. At the receiver, we employ iterative detection and decoding algorithm for data processing in which log likelihood ratios(LLRs) are exchanged between the detector and decoders for determined times. Furthermore, we search for the optimal angle set with the method of maximizing mutual information(MI). We draw the conclusion that the rotations contribute to the performance improvement using extrinsic information transfer(EXIT) charts and bit error rate(BER) curves.

The rest of this paper is organized as follows: In the section II, system model of the spatially coupled multiuser transmission is introduced. We make elaborated theoretical analysis containing constellation rotation, constellation rotation applied in spatial coupling, rotation angles optimization and the iterative detection and decoding algorithm in Section III. The simulation results and analysis are represented in section IV with the help of BER curves and EXIT curves. Finally, section V summarizes this paper.

II. System Model

We consider a scheme where constellation rotation is applied in spatial coupling multiuser data transmission. The system model proposed in this paper is shown in Fig. 1. To simplify the description, we take $\mathbf{b}_{l,s}$ as an example, which represents the sth data stream of user l, $l \in [1,\ldots,L], s \in [1,\ldots,S]$, L and S denote the number of user and data stream per user, respectively. At the transmitter, binary information sequence $\mathbf{b}_{l,s} = \left[\mathbf{b}^T{}_{l,s,1}, \mathbf{b}^T{}_{l,s,2}, \ldots, \mathbf{b}^T{}_{l,s,P}\right]^T$ with P packages are encoded by LDPC encoder with code rate $R = K/N$, where sequence $\mathbf{b}_{l,s,p} = [b_{l,s,p,1}, b_{l,s,p,2}, \ldots, b_{l,s,p,K}]$ and $p \in [1, 2, \ldots, P]$. In

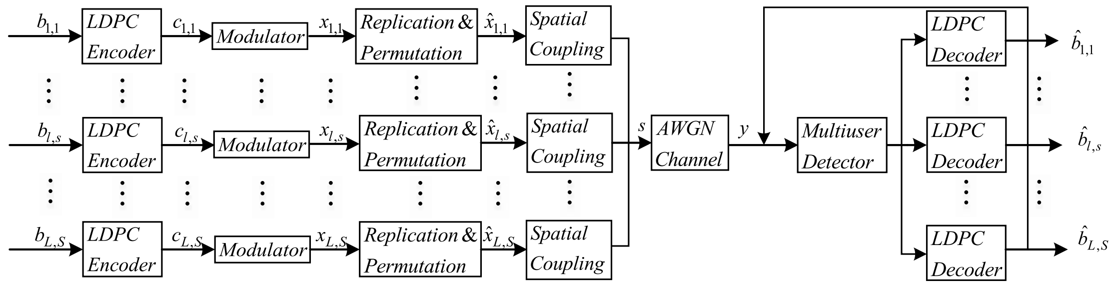

Fig. 1. System model of N user each with L streams.

the modulator, constellation rotation is adopted to modulate the encoded data stream $\mathbf{c}_{l,s}$. The output of the modulator is denoted by sequence $\mathbf{x}_{l,s} = \left[\mathbf{x}^T{}_{l,s,1}, \mathbf{x}^T{}_{l,s,2}, \dots, \mathbf{x}^T{}_{l,s,P}\right]^T$, where $\mathbf{x}_{l,s,p} = \left[x_{l,s,p,1}, x_{l,s,p,2}, \cdots, x_{l,s,p,N}\right]^T$. Then each package of $\mathbf{x}_{l,s}$ is replicated M times and permuted with different interleavers, which produces signal $\hat{\mathbf{x}}_{l,s}$ composed of $\left\{\hat{\mathbf{x}}^1_{l,s,1}, \dots, \hat{\mathbf{x}}^M_{l,s,1}, \dots, \hat{\mathbf{x}}^1_{l,s,P}, \dots, \hat{\mathbf{x}}^M_{l,s,P}\right\}$. $\hat{\mathbf{x}}_{l,s}$ is superimposed on other data streams to generate the signal $\mathbf{s}$ when spatial coupling. We define the system described above as a (L,S)-multiuser spatial coupling structure with P packages and M replications of each package.

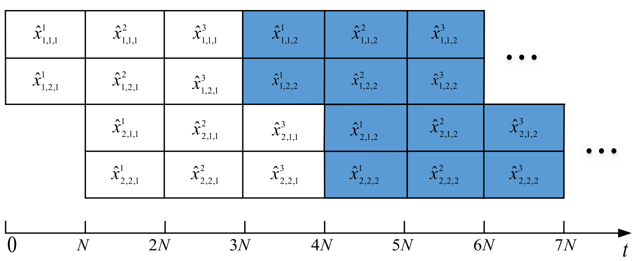

Fig. 2. Coupling of modulated data streams with time offset T in a $(2,2)$-multiuser spatial coupling structure with 3 replications of each package.

Without loss of generality, we consider $(2,2)$-multiuser spatial coupling structure. The spatial coupling procedure is represented in Fig. 2, where each row is a data stream of a user and the packages are transmitted one after another. The block $\hat{\mathbf{x}}^m_{l,s,p}$ can be denoted as $\hat{\mathbf{x}}^m_{l,s,p} = \boldsymbol{\pi}^m{}_{l,s,p}\mathbf{x}_{l,s,p}$, where $\boldsymbol{\pi}^m{}_{l,s,p}$ is the corresponding interleaver. At time $t=0$, two data streams of the first user start to transmit. The signal transmitted adds two data streams of one user each N bit intervals in order until the number of user reaches the limit.

$$H = \begin{bmatrix}
\pi^1{}_{1,1,1} & \cdots & \pi^M{}_{1,1,1} & \cdots\cdots & \pi^1{}_{1,1,P} & \cdots & \pi^M{}_{1,1,P} & & & \\
\pi^1{}_{1,2,1} & \cdots & \pi^M{}_{1,2,1} & \cdots\cdots & \pi^1{}_{1,2,P} & \cdots & \pi^M{}_{1,2,P} & & & \\
\vdots & \cdots & \vdots & \cdots\cdots & \vdots & \cdots & \pi^M{}_{1,S,P} & & & \\
\pi^1{}_{1,S,1} & \cdots & \pi^M{}_{1,S,1} & \cdots\cdots & \pi^1{}_{1,S,P} & \cdots & \pi^M{}_{1,S,P} & & & \\
 & \pi^1{}_{2,1,1} & \cdots & \pi^M{}_{2,1,1} & \cdots\cdots & \pi^1{}_{2,1,P} & \cdots & \pi^M{}_{2,1,P} & & \\
 & \pi^1{}_{2,2,1} & \cdots & \pi^M{}_{2,2,1} & \cdots\cdots & \pi^1{}_{2,2,P} & \cdots & \pi^M{}_{2,2,P} & & \\
 & \vdots & \cdots & \vdots & \cdots\cdots & \vdots & \cdots & \vdots & & \\
 & \pi^1{}_{2,S,1} & \cdots & \pi^M{}_{2,S,1} & \cdots\cdots & \pi^1{}_{2,S,P} & \cdots & \pi^M{}_{2,S,P} & & \\
 & & \ddots & \vdots & \cdots & \vdots & & \vdots & & \\
 & & & \pi^1{}_{L,1,1} & \cdots & \pi^M{}_{L,1,1} & \cdots\cdots & \pi^1{}_{L,1,P} & \cdots & \pi^M{}_{L,1,P} \\
 & & & \pi^1{}_{L,2,1} & \cdots & \pi^M{}_{L,2,1} & \cdots\cdots & \pi^1{}_{L,2,P} & \cdots & \pi^M{}_{L,2,P} \\
 & & & \vdots & \cdots & \vdots & \cdots\cdots & \vdots & \cdots & \vdots \\
 & & & \pi^1{}_{L,S,1} & \cdots & \pi^M{}_{L,S,1} & \cdots\cdots & \pi^1{}_{L,S,P} & \cdots & \pi^M{}_{L,S,P}
\end{bmatrix} \tag{1}$$

We use spatial coupling matrix H to achieve above procedure. The construction of H is shown in (1), where $\boldsymbol{\pi}^m{}_{l,s,p}$ is the permutation matrix of $N \times N$ unit matrix. Therefore, the signal $\mathbf{s}$ can be described as $\mathbf{s} = H^T\mathbf{x}$, where $\mathbf{x} = \left[\mathbf{x}^T{}_{1,1,1}, \cdots, \mathbf{x}^T{}_{1,1,P}, \cdots, \mathbf{x}^T{}_{L,S,1}, \cdots, \mathbf{x}^T{}_{L,S,P}\right]^T$.

When the signal $\mathbf{s}$ passes through the AWGN channel, channel output can be calculated by (2), where λ is the power normalization coefficient, $\mathbf{n}$ is gaussian noise with zero mean and σ^2 variance.

$$\mathbf{y} = \lambda\mathbf{s} + \mathbf{n} \tag{2}$$

At the receiver, iterative detection and decoding based on message passing algorithm(MPA) is performed. Inner the detector and the decoder, the extrinsic messages are iteratively exchanged along edges between channel nodes and variable nodes. For the iteration between detector and decoder, which is also called outer iteration, the output of the detector is transmitted to the decoder, the output of the decoder is used as the input of the detector for next iteration. Note that each package of a data stream is encoded and decoded individually and the maximum number of the outer iteration is defined as $I_{\max}$.

III. PROPOSED SCHEME

A. Constellation rotation

For each data stream, the principle of the constellation rotation we proposed is illustrated in Fig. 3, where the modulated signal is constructed by anticlockwise rotating the signal after BPSK code modulation with a certain angle θ. Assuming $\mathbf{x}'_{l,s}$ denotes the BPSK modulation signal of $\mathbf{c}_{l,s}$,

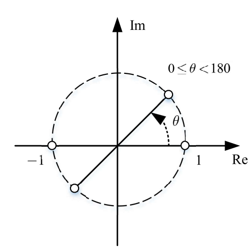

Fig. 3. The constellation rotation of each data stream.

$\mathbf{x}'_{l,s} = \left[\mathbf{x}'^T{}_{l,s,1}, \mathbf{x}'^T{}_{l,s,2}, \cdots, \mathbf{x}'^T{}_{l,s,P}\right]^T$. Then $\mathbf{x}'_{l,s}$ is rotated with angle $\boldsymbol{\theta}_{l,s}$, $\boldsymbol{\theta}_{l,s} \in [0, 180)$, $\mathbf{x}_{l,s}$ can be described as

$$\mathbf{x}_{l,s} = e^{i\boldsymbol{\theta}_{l,s}}\mathbf{x}'_{l,s} \tag{3}$$

B. Constellation rotation applied in spatially coupling

To our knowledge, there exists inevitable interference when different signals are superimposed in spatially coupled multiuser transmission. Therefore, we apply the constellation rotation to make a further distinction between the signals superimposed. We consider the scheme of distinction in a progressive way. First, we deal with the interference between different data streams of each user by rotating them with different angles, and there is no difference between users. It diversifies the constellation of the coupled signal $\mathbf{s}$ and contributes to improving the performance of the system theoretically. However, there is still interference between different users. Then, we use different angles to modulate all different data streams, it expands the diversity at the cost of increasing the implementation complexity. Experimental results show that the increase in complexity is negligible when compared to the improvement of performance.

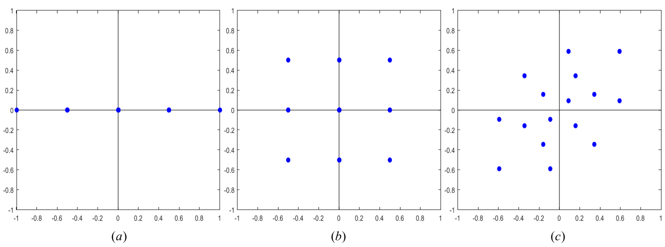

Fig. 4. The constellations of coupled signal $\mathbf{s}$ in (2,2)-multiuser spatial coupling system. Rotation angle sets from left to right are $(0, 0, 0, 0)$, $(0, 90, 0, 90)$, $(0, 30, 60, 90)$, respectively.

We take the system with 2 users and 2 data streams per user as observation, the constellations of $\mathbf{s}$ with different rotation angle sets are shown in Fig. 4. As can be seen from the figure, the constellation of $\mathbf{s}$ containing 16 points when all data streams are modulated with different angles. There are constellation overlapping when different users use the same rotation rule, We also call this phenomenon constellation aliasing. Nonetheless, both of them obtain higher diversity in constellation compared with the system without constellation rotation.

When considering constellation, we naturally come up with the minimum Euclidean distance which reflects the mutual interference between constellation points. The shorter the distance is, the greater the interference is. The minimum Euclidean distance decrease when the diversity of the constellation increase. Therefore, it is necessary to make a trade off between constellation aliasing and mutual interference and search for the optimal rotation angle set.

C. Rotation angles optimization

The optimization of rotation angles is equivalent to find certain angle set with maximum mutual information(MI) between the input $\mathbf{s}$ and the output $\mathbf{y}$. The maximum MI represents the maximum amount of information about $\mathbf{s}$ that can be conveyed through the channel and is also called channel capacity. Assuming the constellation points set of $\mathbf{s}$ is denoted by $\{s_k\}, (k = 1, 2, \cdots, K)$, $s_k = a_k + ib_k$, $y = u + iv$. The channel transition probability is given as

$$\begin{aligned} p(y|s_k) &= \int\int \frac{1}{\pi N_0} e^{-\frac{(u-a_k)^2+(v-b_k)^2}{N_0}} dudv \\ &= \int\int \frac{1}{\pi N_0} e^{-\frac{|y-s_k|^2}{N_0}} dudv \end{aligned} \tag{4}$$

Where N_0 is the noise power spectral density. In order to facilitate the calculation, we assume that $N_0 = 1$. The computational formula of MI is derived as

$$I(\mathbf{s};\mathbf{y}) = \sum_{k=1}^{K} p(s_k) \int\int p(y|s_k) \log \frac{p(y|s_k)}{\sum_{k=1}^{K} p(s_k) p(y|s_k)} dudv \tag{5}$$

The limit of integration above is $(-\infty, +\infty)$. As s_k occurs with equal probability, we combine (4) with (5), and get that:

$$\begin{aligned} &I(\mathbf{s};\mathbf{y}) = \log K - \\ &\frac{1}{K} \sum_{k=1}^{K} \int\int \frac{1}{\pi N_0} e^{-\frac{|y-s_k|^2}{N_0}} \log \sum_{k'=1}^{K} e^{-\frac{|y-s_n|^2+|y-s_k|^2}{N_0}} dudv \end{aligned} \tag{6}$$

In our scheme, we traverse all sets of rotation angle when the total number of data streams LS is determined and select the optimal rotation angles with the maximum MI.

D. Iterative detection and decoding

In this section, we put the process of iteration detection and decoding scheme in detail. During the detection, the log-likelihood ratios(LLRs) are used as the extrinsic information and passed between nodes given in Fig. 5. The received

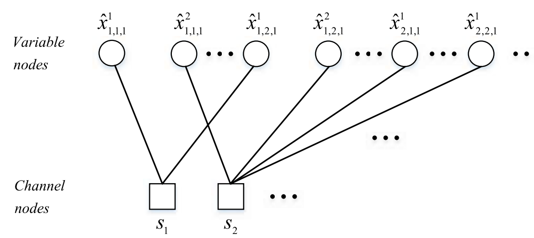

Fig. 5. Factor graph representation of spatial coupling multiple access system, where circles represent variable nodes corresponding to the data blocks in Fig. 2, channel nodes are coupling data and denoted by squares.

message of one node along one edge is not allowed to update the message sent from the same edge. Let the edge between variable node $\hat{x}_{l,s,p}$ and channel node s_t as observation. Set $\xi(l, s, p)\backslash t$ is the index collection of channel nodes connected with variable node $\hat{x}_{l,s,p}$ and set $\xi t\backslash(l, s, p)$ is the index collection of variable nodes connected with channel nodes s_t. Symbol $l_{\hat{x}_{l,s,p}\to s_t}$ and $l_{s_t\to\hat{x}_{l,s,p}}$ represent the message sent from $\hat{x}_{l,s,p}$ and s_t, respectively. We initialize $l_{\hat{x}_{l,s}\to s_t}$ as follows:

$$l_{\hat{x}_{l,s,p}\to s_t} = \log \frac{p(\hat{x}_{l,s,p} = +e^{i\theta_{l,s}})}{p(\hat{x}_{l,s,p} = -e^{i\theta_{l,s}})} \tag{7}$$

The message updated during iteration can be write as:

$$l_{\hat{x}_{l,s,p}\to s_t} = \sum_{t'\in\xi(l,s,p)\backslash t} l_{s_{t'}\to\hat{x}_{l,s,p}} \tag{8}$$

$$\begin{aligned} l_{s_t\to\hat{x}_{l,s,p}} &= \log \frac{p(\hat{x}_{l,s,p} = +e^{i\theta_{l,s}}|s_t, \hat{\mathbf{x}}^{[t]}\backslash\hat{x}_{l,s,p})}{p(\hat{x}_{l,s,p} = -e^{i\theta_{l,s}}|s_t, \hat{\mathbf{x}}^{[t]}\backslash\hat{x}_{l,s,p})} \\ &= \log \frac{p(s_t|\hat{\mathbf{x}}^{[t]}, \hat{x}_{l,s,p} = +e^{i\theta_{l,s}})p(\hat{\mathbf{x}}^{[t]}|\hat{x}_{l,s,p} = +e^{i\theta_{l,s}})}{p(s_t|\hat{\mathbf{x}}^{[t]}, \hat{x}_{l,s,p} = -e^{i\theta_{l,s}})p(\hat{\mathbf{x}}^{[t]}|\hat{x}_{l,s,p} = -e^{i\theta_{l,s}})} \end{aligned} \tag{9}$$

Where $\hat{\mathbf{x}}^{[t]}$ denotes the set containing all signals superimposed on the coupled signal s_t. (9) is derived by using Bayes' rule listed below

$$p(x|y) = \frac{p(y|x)p(x)}{p(y)} \propto p(y|x)p(x) \tag{10}$$

The conditional probability density function(pdf) of the coupled signal s_t and the set $\hat{\mathbf{x}}^{[t]}$ are given separately as:

$$p\left(s_t|\hat{\mathbf{x}}^{[t]}\right) = \frac{1}{\sqrt{2\pi\sigma}} \exp\left(-\frac{1}{2\sigma^2}\left\|s_t - \mathbf{h}^{[t]T}\hat{\mathbf{x}}^{[t]}\right\|^2\right) \tag{11}$$

$$p\left(\hat{\mathbf{x}}^{[t]}|\hat{x}_{l,s,p}\right) = \prod_{(l',s',p')\in\xi t\setminus(l,s,p)} p(\hat{x}_{l',s',p'}) \tag{12}$$

where $\mathbf{h}^{[t]}$ is normalized coefficient vector of $\hat{\mathbf{x}}^{[t]}$,symbol $\|\|$ is modulus operation and a priori probability of $\hat{x}_{l',s',p'}$ is written as:

$$p(\hat{x}_{l',s',p'}) = \exp\left(\frac{\hat{x}_{l',s',p'}}{2} l_{\hat{x}_{l',s',p'}\to s_t}\right) \tag{13}$$

Substituting (11), (12) and (13) into (9), we get (14) shown on the top of next page, where $\max^*$ operation[12] is defined as follows:

$$\begin{aligned} \max{}^*(a,b) &= \log(\exp(a) + \exp(b)) \\ &= \max(a,b) + \log(1 + \exp(-|a-b|)) \end{aligned} \tag{15}$$

We define the iterative process from the detector to the decoder as a whole iteration. The message exchanged between detector and decoder can be described as

$$l_{out,\hat{x}_{l,s,p}}^{DEC[i]} = l_{\hat{x}_{l,s,p}}^{I_{DEC}} - l_{out,\hat{x}_{l,s,p}}^{DET[i]} \tag{16}$$

where the symbol on the left of the equal sign represents the output of the decoder in ith iteration, $i \in [1, \cdots I_{\max}]$. On the right side, the subtrahend is the LLRs of the decoder after I_{DEC} inner iterations and is used for soft decision, the minuend denotes the output of the detector in ith iteration, initialized to 0 when $i = 1$ and is updated as:

$$l_{out,\hat{x}_{l,s,p}}^{DET[i]} = l_{\hat{x}_{l,s,p}}^{I_{DET}} - l_{out,\hat{x}_{l,s,p}}^{DEC[i-1]} \tag{17}$$

where $l_{\hat{x}_{l,s,p}}^{I_{DET}}$ is the total LLRs received from neighbors of $\hat{x}_{l,s,p}$ after I_{DET} iterations. The symbol $l_{out,\hat{x}_{l,s,p}}^{DEC[i-1]}$ is the $i-1$th iterative output of the detector.

IV. SIMULATION RESULTS

In this section, we analyze the system performance using EXIT charts and BER curves. The system settings are as follows: the encoding scheme considered is $(3,6)$-regular LDPC code with length $N = 1800$ and rate $1/2$, the channel noise is complex AWGN with zero mean and $\sigma^2/2$ variance for each dimension, and the maximum numbers of iterations inner detector, inner decoder and between the detector and the decoder are 2, 10 and 20, respectively.

A. EXIT chart

EXIT chart is a useful tool to track the mutual information at each iteration in soft-in soft-out(SISO) system, and it provides an excellent prediction on the behavior of the iteration. We use EXIT charts to evaluate the performance of the detector(or decoders) by observing whether it is conductive to increase the output mutual information I_E when the input extrinsic information I_A is given. We produce the EXIT curve with several input mutual information and the corresponding output of the detector(or decoders).

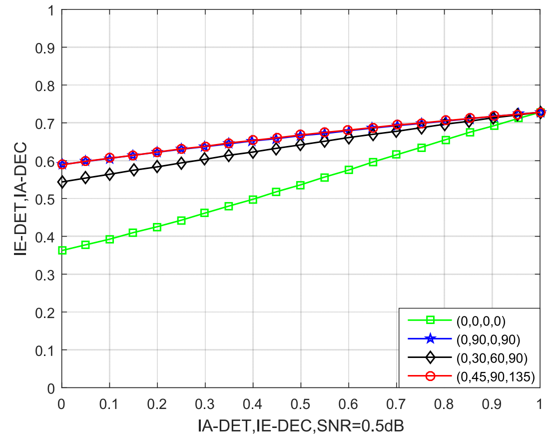

Fig. 6. The EXIT chart of the detector for different rotation angle group in $(2,2)$-multiuser spatial coupling system with SNR = 0.5dB.

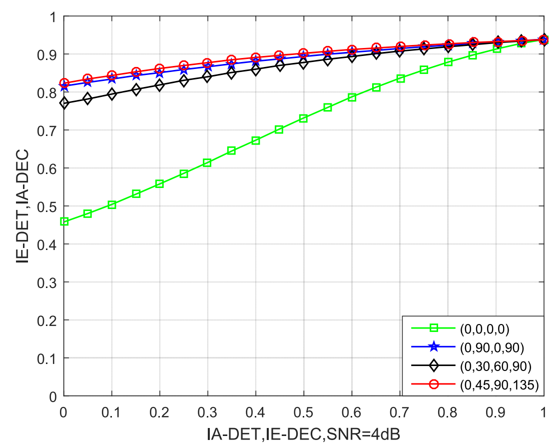

Fig. 7. The EXIT chart of the detector for different rotation angle group in $(2,2)$-multiuser spatial coupling system with SNR = 4dB.

For the sake of generality, we take (2,2)-multiuser spatial coupling structure as an instance. There are two EXIT curves of detector with different rotation angle set over AWGN channel at SNR = 0.5dB shown in Fig. 6 and SNR = 4dB shown in Fig. 7, respectively. According to the figures above, we reach a conclusion that constellation rotation does contribute to increase the output mutual information of the detector. The system performance is influenced by the rotation angle set, when we only consider the interference between two data streams of each user, the optimal rotation angle set is $(0,90,0,90)$, namely, two data streams of a user are perpendicular to each other, which means there exists no interference between certain user's different data streams, but the interference between the two users can not be eliminated and results in the constellation aliasing. When all data streams are taken into account, the diversity of constellation increases. In this case, the optimal rotation angle set we seek out are

$$
\begin{aligned}
l_{s_t \to \hat{x}_{l,s,p}} = & \max_{\substack{\hat{\mathbf{x}}^{[t]} \\ \hat{x}_{l,s,p} = +e^{i\theta_{l,s}}}}^{\star} \left(\sum_{(l',s',p') \in \xi t \setminus (l,s,p)} \frac{\hat{x}_{l,s,p}}{2} l_{\hat{x}_{l,s,p} \to s_t} - \frac{1}{2\sigma^2} \left\| s_t - \mathbf{h}^{[t]T} \hat{\mathbf{x}}^{[t]} \right\|^2 \right) \\
& - \max_{\substack{\hat{\mathbf{x}}^{[t]} \\ \hat{x}_{l,s,p} = -e^{i\theta_{l,s}}}}^{\star} \left(\sum_{(l',s',p') \in \xi t \setminus (l,s,p)} \frac{\hat{x}_{l,s,p}}{2} l_{\hat{x}_{l,s,p} \to s_t} - \frac{1}{2\sigma^2} \left\| s_t - \mathbf{h}^{[t]T} \hat{\mathbf{x}}^{[t]} \right\|^2 \right)
\end{aligned}
\tag{14}
$$

$(0, 90, 45, 135)$. It can be seen that when the SNR is low at $0.5dB$, the performance of the detector for $(0, 90, 45, 135)$ is almost the same as that for $(0, 90, 0, 90)$, that is to say interference plays a dominant role in the factors affecting the performance rather than diversity. On the contrary, when the SNR is high at $4dB$, the performance of detector is better for $(0, 90, 45, 135)$, which means diversity is the main influencing factor. Anyway, both of them perform better than the system with rotation angle sets randomly selected, such as $(0, 30, 60, 90)$.

B. BER curve

We have demonstrated that the constellation rotation is applicable to any spatially coupled multiuser transmission structure. In this subsection, we only take the (2,2) and (3,2)-multiuser spatial coupling structure as observations for simplified analysis, the optimal rotation angle sets we obtain are $(0, 90, 45, 135)$ and $(0, 90, 30, 120, 60, 150)$.

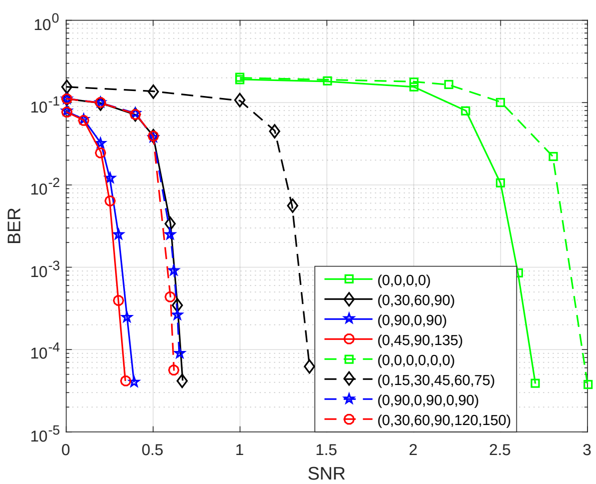

Fig. 8. The average BER curves of different multiuser spatial coupling systems with different rotation angle sets.

We illustrate the average BER curve of the system in Fig. 8, where dotted line and solid line represent the system with the structure $(2, 2)$ and the structure $(3, 2)$, respectively. It can be observed that the system with constellation rotation improves its performance indeed and the optimal rotation angle sets we find out outperform the others in terms of BER performance, which is consistent with the analysis of EXIT charts above. And the performance of the system with constellation rotation converges faster, which is beneficial to reduce the implementation complexity and latency of the system.

CONCLUSION

In this paper, we have applied constellation rotation in spatially coupled multiuser transmission with LDPC coding and iterative detection and decoding algorithm, and sought out the optimal rotation angle set using mutual information. The EXIT charts and BER curve simulation results verify that the constellation rotation benefits to improve the performance of the system and reduce the implementation complexity and latency, the system with the optimal rotation angle set performs significantly better than the others.

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