Abstract. The transport of a self-propelled particle confined in a corrugated channel with Lévy noise is investigated. The parameters of Lévy noise (i.e. the stability index, the asymmetry parameter, the scale parameter, the location parameter) and the parameters of the confined corrugated channel (i.e. the compartment length, the channel width and the bottleneck size) have joint effects on the system. There exist flow reverse phenomena with increasing mean parameters. Left distribution noise will induce $-x$ directional transport and right distribution noise will induce $+x$ directional transport. The distribution skewness will affect the moving direction of the particle. The average velocity shows complex behavior with increasing stability index. The angle velocity and the angle Gaussian noise have little effects on the particle transport.

Keywords: nonlinear dynamics, numerical simulations, self-organized criticality
1. Introduction

Rectification of Brownian motion in a narrow, periodically corrugated channel has been the focus of a concerted effort aimed at establishing net particle transport in the absence of external biases. Some diffusive transports through microstructures are ubiquitous and attract ever-growing attention from physicists [1–6], engineers [7], and biologists [8]. Hänggi et al presented an overview of artificial Brownian motors, attempting to explore future pathways and potential new applications of artificial Brownian motors [9]. Brownian particles in regular arrays of rigid obstacles and also in the corrugated geometry channel show many interesting phenomena.

Self-propelled particles, performing directed motion by extracting energy from the external environment, are rather different from traditional inertia particles, which are dominated by thermal fluctuations. Self-propelled particles confined in a channel have attracted wide attention [10–12]. Ao et al investigated the transport diffusivity of Janus particles in the absence of external biases and found the self-diffusion constants depend on both the strength and the chirality of the self-propulsion mechanism [11]. Ghosh et al investigated the Brownian transport of self-propelled overdamped microswimmers in a two-dimensional periodically compartmentalized channel [13]. Malgaretti et al analyzed the dynamics of Brownian ratchets in a confined environment and found that the combined rectification mechanisms may lead to bidirectional transport [14]. van Teeffelen et al studied the motion of a chiral swimmer in a confining channel and found self-propelled particles move along circles rather than along a straight line when their driving force does not coincide with their propagation direction [15]. Pototsky et al considered a colony of point-like self-propelled surfactant particles without direct interactions that cover a thin liquid layer on a solid support [16].

All of these studies devoted to the self-propelled particles were treating the input noise process as Gaussian noise. In practice, various non-Gaussian noises have distinct spiky and impulsive characteristics; the decay of its probability density function is slower than the Gaussian distribution’s, showing significant tails. The Lévy distribution, which
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is based on the generalized central limit theorem, has the statistical characteristics of a non-Gaussian and is heavy tailed, so it provides a strong theoretical tool for the analysis of the non-Gaussian noises and signals. Lévy noise frequently appears in areas of statistical mechanics, finance, and signal processing, and is more suitable for modeling diversified system noise because it can be decomposed into a continuous part and a jump part by Lévy–Itô decomposition [17–21]. Lévy noise extends Gaussian noise to many types of impulsive jump-noise processes found in real and model neurons, as well as in models of finance and other random phenomena.

In this paper, we investigate the transport phenomenon of self-propelled Brownian particles confined in a 2D corrugated channel with Lévy noise. The paper is organized as follows: in section 2, the basic model of self-propelled particles confined in a 2D channel with Lévy noise is provided. In section 3, the effects of the channel and noise are investigated by means of simulations. In section 4, we get the conclusions.

2. Basic model and methods

In this work, we consider the self-propelled Brownian particles confined in a 2D sinusoidal channel. The dynamics of the particles can be described by the following Langevin equations [22]

\[
\frac{dx}{dt} = v_0 \cos \theta + \xi(t) \tag{1}
\]

\[
\frac{dy}{dt} = v_0 \sin \theta + \xi(t) \tag{2}
\]

\[
\frac{d\theta}{dt} = \omega + \xi_\theta(t) \tag{3}
\]

where \(x\) and \(y\) are the positions of the particle. \(v_0\) is the self-propelled velocity. \(\theta\) is the angle between the moving direction and the x axis. \(\omega\) is chosen so as to coincide respectively with the positive and negative chirality of the swimmer. \(\xi(t)\) is the Lévy noise and obeys Lévy distribution \(L_{\alpha,\beta}(\zeta; \sigma, \mu)\), and the characteristic function is [17]:

\[
\Phi(k) = \int_{-\infty}^{+\infty} d\zeta \exp(ik\zeta)L_{\alpha,\beta}(\zeta; \sigma, \mu) \tag{4}
\]

for \(\alpha \in (0,1) \cup (1,2]\)

\[
\Phi(k) = \exp \left\{ i\mu k - \sigma^\alpha |k|^\alpha \left( 1 - i\beta \text{sgn}(k) \tan \frac{\pi \alpha}{2} \right) \right\} \tag{5}
\]

and for \(\alpha = 1\)

\[
\Phi(k) = \exp \left\{ i\mu k - \sigma |k| \left( 1 + i\beta \text{sgn} \frac{2}{\pi} \ln |k| \right) \right\}. \tag{6}
\]

Here, \(\alpha \in (0,2]\) denotes the stability index that describes an asymptotic power law of the Lévy distribution. When \(\alpha < 2\), \(L_{\alpha,\beta}(\zeta; \sigma, \mu)\) is characterized by a heavy-tail of
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$|\zeta|^{-(\alpha+1)}$ type with $|\zeta| \gg 1$. The constant $\beta$ is the asymmetry parameter with $\beta \in [-1, 1]$. When $\beta$ is positive, the distribution is skewed to the right. When it is negative, the distribution is skewed to the left. When $\beta = 0$, the distribution is symmetrical. As $\alpha \to 2$, the distribution approaches the symmetrical Gaussian distribution regardless of $\beta$. $\sigma$ is the scale parameter with $\sigma \in (0, \infty)$, $\mu (\mu \in \mathbb{R})$ denotes the location parameter, and $D = \sigma^\alpha$ represents the noise intensity. In this paper, we use the Janicki–Weron algorithm to generate the Lévy distribution [17].

As $\alpha \neq 1$, $\xi$ is simulated as

$$\xi = D_{\alpha,\beta,\sigma} B_{\alpha,\beta} \left\{ \frac{\cos(M - \alpha(M + C_{\alpha,\beta}))}{W} \right\}^{(1-\alpha)/\alpha} + \mu. \quad (7)$$

As $\alpha = 1$, $\xi$ can be obtained from the formula

$$\xi = \sigma \frac{2}{\pi} \left\{ \left( \frac{\pi}{2} + \beta M \right) \tan(M) - \beta \ln \left( \frac{W \cos(M)}{\frac{\pi}{2} + \beta M} \right) \right\} + \frac{2}{\pi} \beta \sigma \ln \sigma + \mu. \quad (8)$$

The constants $B_{\alpha,\beta}, C_{\alpha,\beta}, D_{\alpha,\beta,\sigma}$ are given by

$$B_{\alpha,\beta} = \frac{\sin(\alpha(M + C_{\alpha,\beta}))}{(\cos(M))^{1/\alpha}} \quad (9)$$

$$C_{\alpha,\beta} = \frac{\arctan(\beta \tan(\frac{\pi \alpha}{2}))}{\alpha} \quad (10)$$

$$D_{\alpha,\beta,\sigma} = \sigma \left\{ 1 + \beta^2 \tan^2 \left( \frac{\pi \alpha}{2} \right) \right\}^{1/2\alpha} \quad (11)$$

$M$ is a random variable uniformly distributed over $(-\pi/2, \pi/2)$. $W$ is a random variable exponentially distributed with a unit mean. $M$ and $W$ are statistically independent [17, 23, 24].

$\xi_\theta$ is the self-propelled angle Gaussian color noise, and describes the nonequilibrium angular fluctuation. $\xi_\theta$ satisfies the following relations

$$\langle \xi_\theta(t) \rangle = 0 \quad (12)$$

$$\langle \xi_\theta(t) \xi_\theta(t') \rangle = Q_\theta \frac{\exp \left( -\frac{|t - t'|}{\tau_\theta} \right)}{\tau_\theta} \quad (13)$$

where $\langle \cdots \rangle$ denotes an ensemble average over the distribution of the random forces. $Q_\theta$ is the noise intensity, $\tau_\theta$ the self-correlation time.

The confined corrugated channel is a periodic function in space along the $x$ direction (depicted in figure 1). The walls of the cavity have been modelled by the following function

$$W_+(x) = \frac{1}{2} \left\{ \Delta + \epsilon (y_L - \Delta) \sin^2 \left( \frac{\pi}{x_L} x + \frac{\phi}{2} \right) \right\} \quad (14)$$

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$$W_-(x) = -\frac{1}{2} \left\{ \Delta + (y_L - \Delta) \sin^2 \left( \frac{\pi x}{x_L} \right) \right\}. \quad (15)$$

The upper and lower boundary functions are $W_+(x)$ and $W_-(x)$, respectively. $x_L$ is the compartment length, $y_L$ the channel width, and $\Delta$ the bottleneck size. There are two geometrical parameters introduced in $W_+(x)$ for varying the upside-down asymmetric degree, namely $\epsilon$ and $\phi$. $\epsilon$ is defined as a real number for tuning the amplitude of the upper wall compared to the lower wall, and $\phi$ is for tuning the shift of the upper wall from corresponding position of lower wall.

A central practical question in the theory of Brownian motors is the overall long time behavior of the particle, and the key quantities of particle transport is the particle velocity $\langle V \rangle$. Because particles along the $y$ direction are confined, we only calculate the $x$ direction average velocity
$$\langle V_{\theta_0} \rangle = \lim_{t \to \infty} \frac{\langle x(t) - x(t_0) \rangle}{t - t_0} \quad (16)$$
where $x(t_0)$ is the position of particles at time $t_0$. $\theta_0$ is initial angle of the trajectory. The full average velocity after another average overall $\theta_0$ is
$$\langle V \rangle = \frac{1}{2\pi} \int_0^{2\pi} \langle V_{\theta_0} \rangle d\theta_0. \quad (17)$$

3. Results and discussion

In order to give a simple and clear analysis of the system, equations (1)–(3) are integrated using the Euler algorithm. In our simulations, the integration step time $\Delta t = 10^{-4}$ and the total integration time was more than $5 \times 10^5$ and the transient effects were estimated and subtracted. The stochastic averages reported above were obtained as ensemble averages over $2 \times 10^4$ trajectories with random initial conditions.

We know that the mean parameter $\mu$ shifts the distribution to the left ($\mu < 0$) or right ($\mu > 0$). The average velocity $\langle V \rangle$ as a function of mean parameter $\mu$ with different asymmetry parameters $\beta$ is reported in figure 2. In this figure, we find $\langle V \rangle$ increases with increasing $\mu$. The moving direction changes from against the $x$ axis to along the $x$ axis with increasing $\mu$, so the transport reverse phenomenon appears with increasing mean parameter $\mu$. The transport reverse point coordinates $\mu_{\text{trp}} < 0$ when $\beta = -0.8$, $\mu_{\text{trp}} = 0$ when $\beta = 0$, and $\mu_{\text{trp}} > 0$ when $\beta = 0.8$. When the asymmetry parameter $\beta = 0$, the left distribution induces $-x$ directional transport, and the right distribution induces $x$ directional transport. When $\beta < 0$ ($\beta = -0.8$), the turning point moves to the left because the distribution is skewed to the left. When $\beta > 0$ ($\beta = 0.8$), the turning point moves to the right as the distribution is skewed to the right. In this figure, we also find the smaller the $\beta$, the larger $\langle V \rangle$ is.

The asymmetry parameter $\beta(-1 \leq \beta \leq 1)$ determines the skewness of the distribution. The average velocity $\langle V \rangle$ as a function of $\beta$ with different $\mu$ is reported in figure 3. When $\mu = 1.0$ (right distribution), $\langle V \rangle > 0$ and $\langle V \rangle$ decreases with increasing $\beta$, so right skewed distribution will inhibit the particle transport in the $x$ direction. When $\mu = 0.0$,
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Figure 1. Schematic of the corrugated channel with different asymmetries: (a) $\varepsilon = 0.5$, $\Delta = 0.0$, $\phi = \pi$; (b) $\varepsilon = 0.5$, $\Delta = 0.5$, $\phi = \pi$; (c) $\varepsilon = 0.5$, $\Delta = 1.0$, $\phi = \pi$; (d) $\varepsilon = 0.5$, $\Delta = 1.5$, $\phi = \pi$; (e) $\varepsilon = -0.1$, $\Delta = 0.5$, $\phi = \pi$; (f) $\varepsilon = 0.0$, $\Delta = 0.5$, $\phi = \pi$; (g) $\varepsilon = 0.1$, $\Delta = 0.5$, $\phi = \pi$; (h) $\varepsilon = 1.5$, $\Delta = 0.5$, $\phi = \pi$.  

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Figure 2. The average velocity $\langle V \rangle$ as a function of mean parameter $\mu$ with different asymmetry parameters $\beta$. The other parameters are $\epsilon = 0.5$, $\Delta = 0.5$, $\phi = \pi$, $\alpha = 1.2$, $\sigma = 0.5$, $v_0 = 0.1$, $\omega = 0.2$, $x_L = y_L = 1.0$, $Q_\theta = 0.2$, and $\tau_\theta = 1.0$.

with increasing $\beta$, the moving direction changes from along the $x$ axis to against the $x$ axis, and the turning point is $\beta = 0$. When $\mu = -1.0$ (left distribution), $\langle V \rangle < 0$ and the moving speed $|\langle V \rangle|$ increases with increasing $\beta$, so large $\beta$ is good for particle directional transport in the $-x$ direction. We know left (right) distribution induces $-x(+x)$ directional transport (in figure 2), but left(right) skewed distribution induces $+x(-x)$ directional transport, so the moving direction is determined by the joint effects of $\mu$ and $\beta$.

The average velocity $\langle V \rangle$ as a function of stability index $\alpha$ with different asymmetries $\beta$ is reported in figure 4. It is found that $\langle V \rangle$ shows complex behavior with increasing $\alpha$. In figure 4(a) ($\mu = -1$), when $\beta = -0.8$, $\langle V \rangle$ decreases with increasing $\alpha$ and reaches a minimum when $\alpha = 0.9$, then $\langle V \rangle$ increases with increasing $\alpha$ and reaches a maximum when $\alpha = 1.1$, and then $\langle V \rangle$ decreases with increasing $\alpha$ when $\alpha > 1.1$. In figure 4(a), when $\beta = 0.0$, $\langle V \rangle$ decreases monotonically with increasing $\alpha$, so large $\alpha$ is good for particle directional transport in the $-x$ direction. In figure 4(a), when $\beta = 0.8$, $\langle V \rangle$ has a maximum with increasing $\alpha$ and the transport reverse phenomenon appears with increasing $\alpha$. In figure 4(b) ($\mu = 1$), when $\beta = -0.8$, there exists a minimum with increasing $\alpha$ and the transport reverse phenomenon appears with increasing $\alpha$. In figure 4(b), when $\beta = 0.0$, $\langle V \rangle > 0$ and $\langle V \rangle$ increases monotonically with increasing $\alpha$, so large stability index is good for particle directional transport in the $x$ direction. In figure 4(b), when $\beta = 0.8$, there exist a maximum and a minimum with increasing $\alpha$. In this figure, we find the $\langle V \rangle - \alpha$ lines will coincide with each other when $\alpha \geq 1.3$. The reason for this is that the larger the stability, the stronger the impact of the noise.

The average velocity $\langle V \rangle$ as a function of scale parameter $\sigma$ with different $\beta$ is reported in figure 5. In figure 5(a) ($\mu = -1.0$), when $\beta = -0.8$ and $\beta = 0.0$, we find $\langle V \rangle$
Figure 3. The average velocity $\langle V \rangle$ as a function of asymmetry parameter $\beta$ with different mean parameters $\mu$. The other parameters are $\epsilon = 0.5$, $\Delta = 0.5$, $\phi = \pi$, $\alpha = 1.2$, $\sigma = 0.5$, $v_0 = 0.1$, $\omega = 0.2$, $x_L = y_L = 1.0$, $Q_\theta = 0.2$, and $\tau_\theta = 1.0$.

Figure 4. The average velocity $\langle V \rangle$ as a function of stability index $\alpha$ with different asymmetry parameters $\beta$. The other parameters are $\epsilon = 0.5$, $\Delta = 0.5$, $\phi = \pi$, $\sigma = 0.5$, $v_0 = 0.1$, $\omega = 0.2$, $Q_\theta = 0.2$, and $\tau_\theta = 1.0$: (a) $\mu = -1.0$, (b) $\mu = 1.0$.

increases with increasing $\sigma$ and the transport reverse phenomenon appears with increasing $\sigma$, so small values of $\sigma$ will help particle directional transport in the $-x$ direction, but large $\sigma$ will help particle transport in the $x$ direction. In figure 5(a), when $\beta = 0.8$, $\langle V \rangle < 0$ and $\langle V \rangle$ decrease with increasing $\sigma$, so large $\sigma$ will help particle directional transport in the $-x$ direction. In figure 5(b) ($\mu = 1.0$), when $\beta = -0.8$ and $\beta = 0.0$, the particle moves in the $x$ direction and large $\sigma$ helps particle direction transport ($\langle V \rangle > 0$.

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Figure 5. The average velocity $\langle V \rangle$ as a function of scale parameter $\sigma$ with different asymmetry parameters $\beta$. The other parameters are $\epsilon = 0.5$, $\Delta = 0.5$, $\phi = \pi$, $\alpha = 1.2$, $v_0 = 0.1$, $\omega = 0.2$, $x_L = y_L = 1.0$, $Q_{\theta} = 0.2$, and $\tau_{\theta} = 1.0$: (a) $\mu = -1.0$, (b) $\mu = 1.0$.

Figure 6. The average velocity $\langle V \rangle$ as a function of $\epsilon$ with different asymmetry parameters $\beta$. The other parameters are $\Delta = 0.5$, $\phi = \pi$, $\alpha = 1.2$, $\sigma = 0.5$, $v_0 = 0.1$, $\omega = 0.2$, $x_L = y_L = 1.0$, $Q_{\theta} = 0.2$, and $\tau_{\theta} = 1.0$: (a) $\mu = -1.0$, (b) $\mu = 1.0$.

and $\langle V \rangle$ increase with increasing $\sigma$). When $\beta = 0.8$, $\langle V \rangle$ decreases with increasing $\sigma$ and the transport reverse phenomenon appears.

Figure 6 shows the average velocity $\langle V \rangle$ as a function of $\epsilon$ with different $\beta$. In the case of $\mu = -1.0$ (figure 6(a)), $\langle V \rangle$ decreases slowly with increasing $\epsilon$ when $\beta = -0.8$. When $\beta = 0.0$, there exists an un conspicuous minimum $\langle \langle V \rangle \rangle_{\min} \approx -2.09$ when $\epsilon = 0$.
Figure 7. The average velocity $\langle V \rangle$ as a function of bottleneck size $\Delta$ with different asymmetry parameters $\beta$. The other parameters are $\epsilon = 0.5$, $\phi = \pi$, $\alpha = 1.2$, $\sigma = 0.5$, $v_0 = 0.1$, $\omega = 0.2$, $x_L = y_L = 1.0$, $Q_\theta = 0.2$, and $\tau_\theta = 1.0$: (a) $\mu = -1.0$, (b) $\mu = 1.0$.

Figure 8. The average velocity $\langle V \rangle$ as a function of $\phi$ with different asymmetry parameters $\beta$. The other parameters are $\epsilon = 0.5$, $\Delta = 0.5$, $\alpha = 1.2$, $\sigma = 0.5$, $v_0 = 0.1$, $\omega = 0.2$, $x_L = y_L = 1.0$, $Q_\theta = 0.2$, and $\tau_\theta = 1.0$: (a) $\mu = -1.0$, (b) $\mu = 1.0$.

with increasing $\epsilon$. When $\beta = 0.8$, there exists an obvious minimum $\langle V \rangle_{\text{min}} \approx -2.65$ when $\epsilon = 0$ with increasing $\epsilon$ and $\langle V \rangle$ decreases with increasing $\epsilon$ when $\epsilon > 0.1$. In the case of $\mu = 1.0$ (figure 6(b)), we find $\langle V \rangle \geq 0$ and $\langle V \rangle$ shows a complex appearance with increasing $\epsilon$. The $\langle V \rangle - \epsilon$ curve has the same shape for different $\beta$ ($\beta = -0.8$, $\beta = 0.0$ and $\beta = 0.8$). $\langle V \rangle$ has a large value when $\epsilon = -0.1$, and decreases quickly to zero when
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Figure 9. The average velocity $\langle V \rangle$ as a function of angular velocity $\omega$ with different asymmetry parameters $\beta$. The other parameters are $\epsilon = 0.5$, $\Delta = 0.5$, $\phi = \pi$, $\alpha = 1.2$, $\sigma = 0.5$, $v_0 = 0.1$, $x_L = y_L = 1.0$, $Q_\theta = 0.2$, and $\tau_\theta = 1.0$: (a) $\mu = -1.0$, (b) $\mu = 1.0$.

Figure 10. The average velocity $\langle V \rangle$ as a function of $v_0$ with different asymmetry parameters $\beta$. The other parameters are $\epsilon = 0.5$, $\Delta = 0.5$, $\phi = \pi$, $\alpha = 1.2$, $\sigma = 0.5$, $\omega = 0.2$, $x_L = y_L = 1.0$, $Q_\theta = 0.2$, and $\tau_\theta = 1.0$: (a) $\mu = -1.0$, (b) $\mu = 1.0$.

$\epsilon = 0.0$, and then increases quickly to a large value when $\epsilon = 0.1$, and decreases to small value (about zero) when $\epsilon > 1.3$.

Figure 7 shows $\langle V \rangle$ as a function of $\Delta$ with different $\beta$. When $\mu = -1.0$ (figure 7(a)), $\langle V \rangle \leq 0$. When $\mu = 1.0$ (figure 7(b)), $\langle V \rangle \geq 0$. In figure 7(a), $\langle V \rangle \approx 0$ when $\Delta \leq 0.3$, and $\langle V \rangle$ decreases to a minimum when $\Delta = 0.9$, and increases to zero when $\Delta = 1.0$ (whenever $\beta = 0.8$, $\beta = 0.0$ and $\beta = 0.8$), and decreases to another minimum when $\Delta = $.
Figure 11. The average velocity $\langle V \rangle$ as a function of noise intensity $Q_\theta$ with different asymmetry parameters $\beta$. The other parameters are $\epsilon = 0.5$, $\Delta = 0.5$, $\phi = \pi$, $\alpha = 1.2$, $\sigma = 0.5$, $v_0 = 0.1$, $\omega = 0.2$, $x_L = y_L = 1.0$, and $\tau_\theta = 1.0$: (a) $\mu = -1.0$, (b) $\mu = 1.0$.

Figure 12. The average velocity $\langle V \rangle$ as a function of self-correlation time $\tau_\theta$ with different asymmetry parameters $\beta$. The other parameters are $\epsilon = 0.5$, $\Delta = 0.5$, $\phi = \pi$, $\alpha = 1.2$, $\sigma = 0.5$, $v_0 = 0.1$, $\omega = 0.2$, $x_L = y_L = 1.0$, $Q_\theta = 0.2$, and $\tau_\theta = 1.0$: (a) $\mu = -1.0$, (b) $\mu = 1.0$.

1.1, and then increases to zero again when $\Delta = 1.6$ (whenever $\beta = 0.8$, $\beta = 0.0$ and $\beta = 0.8$). Generally, the $\langle V \rangle$–$\Delta$ curve forms the shape of the letter ‘W’ when $\mu = -1.0$. In the case of $\mu = 1.0$ (figure 7(b)), the $\langle V \rangle$–$\Delta$ curve forms the shape of the letter ‘M’.

Figures 8 and 9 show $\langle V \rangle$ as functions of $\phi$ ($\phi$ is for tuning the shift of the upper wall from the corresponding position of the lower wall) and the angular velocity $\omega$. We
find $\langle V \rangle$ almost remains unchanged with increasing $\phi$ and $\omega$, which meansthat changes of $\phi$ or $\omega$ have no effect on the directional transport.

The dependence of $\langle V \rangle$ on the self-propelled speed $v_0$ with different $\beta$ is shown in figure 10. In figure 10(a) ($\mu = -1.0$), we find $\langle V \rangle < 0$ and $\langle V \rangle$ has a maximum with increasing $v_0$, so proper self-propelled speed will inhibit the particle directional transport in the $-x$ direction. $\langle V \rangle \neq 0$ when $v_0 = 0$, which means that inert particle confined in the channel will move in the $-x$ direction. In figure 10(b) ($\mu = 1.0$), $\langle V \rangle$ decreases with increasing self-propelled speed $v_0$. So large $v_0$ will inhibit the particle moving in the $x$ direction.

The average velocity $\langle V \rangle$ as functions of noise intensity $Q_\theta$ and self-correlation time $\tau_\theta$ with different $\beta$ is reported in figures 11 and 12. We find there is almost no change for $\langle V \rangle$ with increasing $Q_\theta$ or $\tau_\theta$, so angle Gaussian noise has little effect on the particle transport.

4. Conclusions

In this paper, we numerically studied the transport phenomenon of self-propelled particles confined in a corrugated channel with Lévy noise. The parameters of Lévy noise, i.e. the stability index, the asymmetry parameter, the scale parameter, the location parameter and the parameters of confined corrugated channel, have joint effects on the particle. There exist flow reverse phenomena with increasing mean parameter. $\langle V \rangle$ shows complex behavior with increasing stability index. The $\langle V \rangle - \Delta$ curve forms the shape of $W$ when the distribution is skewed to the left. The $\langle V \rangle - \Delta$ curve forms the shape of $M$ when the distribution is skewed to the right. Angle Gaussian noise has little effect on the particle transport.

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