8. Rest-Motion at moving in a Spiral

8.1. *A case of constant specific velocities*

If rectilinear radial motion is combined with circular motion, complex spiral motion will result, which in the case of constant specific velocities is described by a set of the form

$$\hat{\psi}_x = re^{-i\omega t}, \quad \hat{\psi}_y = ire^{-i\omega t}, \quad \text{где} \quad r = ae^{\beta t}. \qquad 2.178)$$

Here ω is the specific circular or azimuth velocity and β is the specific radial velocity.

The radial velocity is longitudinal and the azimuth velocity is transverse. Spiral motion is movement along an instantaneous azimuth circle or a radial circle of radius r and radial motion along the radius.

The potential-kinetic radius of spiral motion, according to (2.105), should be equal to $\hat{\mathbf{r}} = r\mathbf{n} + ir\tau$.

Therefore, the potential-kinetic velocity of spiral motion can be expressed as

$$\hat{\upsilon} = (\beta - i\omega)\hat{\mathbf{r}}. \qquad (2.179)$$

The velocity (2.179) defines the specific potential-kinetic velocity

$$\hat{\omega} = \omega_p + \omega_k = (-i\omega\mathbf{n} + i\beta\boldsymbol{\tau}) + (\beta\mathbf{n} + \omega\boldsymbol{\tau}) \qquad (2.180)$$

and corresponding to its the moment of momentum

$$\hat{\mathbf{L}} = mr^2\hat{\omega} = J\hat{\omega}. \qquad (2.181)$$

Let us write the velocity on the form of sum of radial and azimuth velocities

$$\hat{\upsilon} = \hat{\upsilon}_r + \hat{\upsilon}_a, \qquad (2.182)$$

where

$$\upsilon_r = (\beta r - i\omega r)\mathbf{n}, \qquad (2.182a)$$

is the radial velocity;

$$\upsilon_a = (\omega r + i\beta r)\boldsymbol{\tau} \qquad (2.182b)$$

is the azimuth velocity.

Radial and azimuth velocities are equal by modulus. If $\beta > 0$, the first component of the radial velocity $\beta r\mathbf{n}$ is the kinetic centrifugal velocity of radial motion; if $\beta < 0$, it is the kinetic centripetal velocity. The second component, $-i\omega r\mathbf{n}$, is the potential centripetal velocity of circular motion.

The first component of the azimuth velocity $\omega r\boldsymbol{\tau}$ is the kinetic tangential velocity of circular motion, the second component, $i\beta r\boldsymbol{\tau}$, is the potential velocity of the radial motion (Fig. 2.10a).

We will rewrite the velocity formula on the form of sum of the potential and kinetic velocities

$$\hat{\upsilon} = \upsilon_p + \upsilon_k, \qquad (2.183)$$

where

$$\upsilon_p = -i\omega r\mathbf{n} + i\beta r\boldsymbol{\tau} \qquad (2.183a)$$

is the potential velocity;

$$\upsilon_k = \beta r\mathbf{n} + \omega r\boldsymbol{\tau} \qquad (2.183b)$$

is the kinetic velocity.

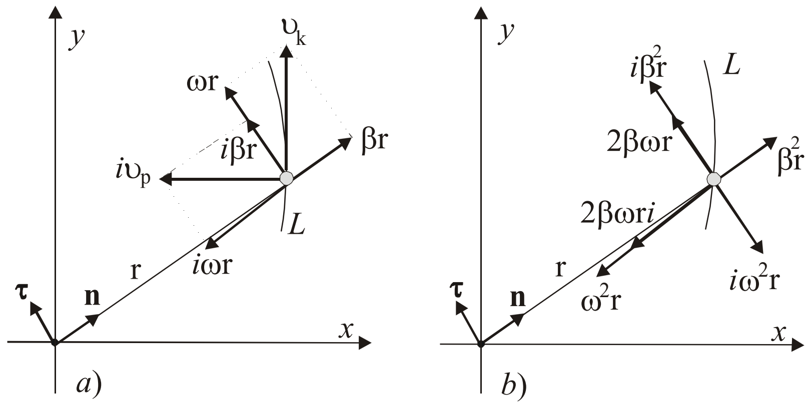

Fig. 2.10. Graph of velocities and accelerations in spiral motion-rest with constant specific velocities ω and β.

The structure of the potential-kinetic velocity is as follows: the first potential radial velocity $-i\omega r\mathbf{n}$ is perpendicular to the azimuth velocity $\omega r\boldsymbol{\tau}$, both the velocities form the unique complex of spiral rest-motion; the second potential azimuth velocity $i\beta r\boldsymbol{\tau}$ is perpendicular to the kinetic radial velocity $\beta r\mathbf{n}$ and forms with the letter also the unique complex of the motion.

Velocities $\omega r\boldsymbol{\tau}$ and $-i\omega r\mathbf{n}$ describe the azimuth variation of the kinematic radius-vector $\hat{\mathbf{r}}$, variation by direction, i.e. the qualitative change.

Velocities $\beta r\mathbf{n}$ and $i\beta r\boldsymbol{\tau}$ determine the radial variation of the kinematic radius-vector $\hat{r}$, variation by value, i.e. the quantitative change.

Potential and kinetic velocities are equal by modulus that expresses the equality of rest and motion. Consequently, the total potential-kinetic energy of spiral motion of a material point is zero that should be expected.

Now we will write acceleration as a sum of radial and azimuth accelerations. As consistent with (2.179), the acceleration in the motion (Fig. 10b) is

$$\hat{\mathbf{w}} = \mathbf{w}_r + \mathbf{w}_a = (\beta - i\omega)^2 \hat{\mathbf{r}}, \tag{2.184}$$

where

$$\mathbf{w}_r = (\beta^2 - 2\omega\beta ri - \omega^2) r\mathbf{n}, \tag{2.184a}$$

$$\hat{\mathbf{w}}_a = (\beta^2 - 2\omega\beta ri - \omega^2) ri\boldsymbol{\tau}. \tag{2.184b}$$

The potential-kinetic structure of the acceleration is as defined below

$$\hat{\mathbf{w}} = \mathbf{w}_p + \mathbf{w}_k \tag{2.185}$$

where

$$\mathbf{w}_p = (\beta^2 - \omega^2) r\mathbf{n} + 2\omega\beta r\boldsymbol{\tau} \tag{2.185a}$$

is the kinetic acceleration;

$$\mathbf{w}_k = (-2\omega\beta) ir\mathbf{n} + (\beta^2 - \omega^2) ir\boldsymbol{\tau} \tag{2.185b}$$

is the potential acceleration.

The acceleration defines the potential-kinetic kinema F and its moment M:

$$\hat{\mathbf{F}} = m\hat{\mathbf{w}} = mr\hat{\varepsilon}\,, \quad \hat{\mathbf{M}} = \hat{\mathbf{F}}r = mr\hat{\mathbf{w}} = mr^2\hat{\varepsilon} = J\hat{\varepsilon}\,, \tag{2.186}$$

where

$$\hat{\varepsilon} = \hat{\varepsilon}_p + \hat{\varepsilon}_k\,, \tag{2.187}$$

with

$$\hat{\varepsilon}_p = (\beta^2 - \omega^2)\mathbf{n} + 2\omega\beta\,\boldsymbol{\tau}\,, \tag{2.187a}$$

$$\varepsilon_k = (-2\omega\beta)i\mathbf{n} + (\beta^2 - \omega^2)i\boldsymbol{\tau}\,. \tag{2.187b}$$

We will consider the velocity of variation of angular momentum:

$$\hat{\mathbf{M}}_L = \frac{d\hat{\mathbf{L}}}{dt} = \frac{dJ}{dt}\hat{\omega} + J\hat{\varepsilon} = 2J\beta\hat{\omega} + J\hat{\varepsilon} \quad \text{or} \quad \hat{\mathbf{M}}_L = V_J\hat{\omega} + \hat{\mathbf{M}}\,, \tag{2.188}$$

where $V_J = \dfrac{dJ}{dt}$ is the velocity of variation of the moment of inertia and $\hat{\mathbf{M}} = J\hat{\varepsilon}$ is the moment of kinema. If $\beta \to 0$, the motion becomes circular and $\hat{\mathbf{M}}_L = \hat{\mathbf{M}}$.

The instantaneous specific velocity along a tangent to a spiral is

$$\hat{\omega}_\rho = \omega_p + \omega_k = \left[(-i\omega r\mathbf{n} + i\beta r\boldsymbol{\tau}) + (\beta r\mathbf{n} + \omega r\boldsymbol{\tau})\right]/\,\rho\,, \tag{2.189}$$

where $\rho = \sqrt{1+\beta^2}\,ae^{\beta t}$ is the curvature radius of the spiral. Hence,

$$\hat{\omega}_\rho = \omega_p + \omega_k = \left[(-i\omega r\mathbf{n} + i\beta r\boldsymbol{\tau}) + (\beta r\mathbf{n} + \omega r\boldsymbol{\tau})\right]/\sqrt{1+\beta^2}\,, \tag{2.189a}$$

The instantaneous moment of momentum along a tangent to the spiral is

$$\hat{\mathbf{L}} = J_\rho\hat{\omega}_\rho = J\hat{\omega}\sqrt{1+\beta^2}\,, \tag{2.190}$$

where $J_\rho = m\rho^2$ and $J = mr^2$ are moments of inertia at the tangent and radial circles.

8.2. ***Rest-motion with variable specific velocities***

We describe spiral motion with the variable specific velocities by equations:

$$\hat{\psi}_x = re^{-i\varphi}\,, \quad \hat{\psi}_y = ire^{-i\varphi}\,, \quad \text{where} \quad r = ae^{\theta} \tag{2.191}$$

The potential-kinetic velocity at this motion is

$$\hat{\upsilon} = (\beta - i\omega)\hat{\mathbf{r}}\,, \quad \text{where} \quad \beta = \frac{d\theta}{dt}\,, \quad \omega = \frac{d\varphi}{dt}\,, \quad \hat{\mathbf{r}} = r(\mathbf{n} + i\boldsymbol{\tau})\,. \tag{2.192}$$

The derivative of the velocity defines the potential-kinetic acceleration

$$\hat{\mathbf{w}} = \hat{\mathbf{w}}_p + \hat{\mathbf{w}}_k = \left[(\eta - i\varepsilon) + (\beta - i\omega)^2\right]r(\mathbf{n} + i\boldsymbol{\tau})\,, \tag{2.193}$$

where $\eta = \dfrac{d\beta}{dt}$ is the specific radial acceleration, $\varepsilon = \dfrac{d\omega}{dt}$ is the specific azimuth acceleration.
Potential and kinetic components of the acceleration are

$$\mathbf{w}_p = (\eta + \beta^2 - \omega^2) r\mathbf{n} + (\varepsilon + 2\omega\beta) r\boldsymbol{\tau}\,, \qquad (2.193a)$$

$$\mathbf{w}_k = (-\varepsilon - 2\beta\omega) ir\mathbf{n} + (\eta + \beta^2 - \omega^2) ir\boldsymbol{\tau}\,. \qquad (2.193b)$$

8.3. *Logical and physical structure of potential and kinetic accelerations*

We will analyze the structure of potential and kinetic accelerations (Fig. 2.11) taking into account that the specific radial velocity β is the velocity of quantitative affirmation and the azimuth velocity ω is the velocity of qualitative negation with the modulus ω and modus $i\omega$.

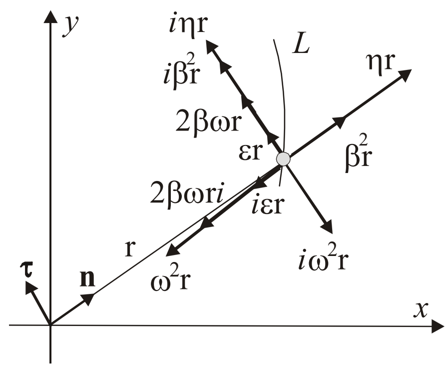

Fig. 2.11. A vector graph of accelerations in spiral rest-motion with the variable specific velocities ω and β.

The **potential acceleration** has the components given below.

a) Acceleration of affirmation of affirmation (Yes-Yes) is the centrifugal acceleration:

$$+\beta^2 r\mathbf{n}\,;$$

b) Acceleration of polar negation of polar negation or acceleration of double polar negation (iNoiNo) or, briefly, acceleration of double negative negation (-No'No) is the centripetal acceleration:

$$-\omega^2 r\mathbf{n}\,;$$

c) Acceleration of affirmation of double polar negation [Yes (-iNo)(iNo)] or acceleration of affirmation of negation (YesNo) is the tangential acceleration:

$$\beta(-i\omega)(ir)\boldsymbol{\tau} = \beta\omega r\boldsymbol{\tau}\,;$$

d) Acceleration of negation of affirmation (No-Yes) is the tangential acceleration:

$$\omega\beta r\boldsymbol{\tau}\,;$$

e) The sum of accelerations (c) and (d) defines the transverse potential Coriolis acceleration:

$$2\omega\beta r\boldsymbol{\tau} \text{ or } 2\omega u_r\boldsymbol{\tau}\,,$$

where $u_r = \beta r$ is the radial kinetic velocity.

f) Non-uniformity of restis defined by normal and tangential accelerations:

$$\eta r\mathbf{n} + \varepsilon r\boldsymbol{\tau}.$$

The **kinetic acceleration** is polar negation of potential acceleration.

a) Acceleration of polar negation of double affirmation (iYesYes) is the tangential acceleration:

$$i\beta^2 r\boldsymbol{\tau};$$

b) Acceleration of negation of double polar negation [iNo (iNoiNo)] is the tangential acceleration:

$$-i\omega^2 r\boldsymbol{\tau};$$

c) Acceleration of affirmation of polar negation [Yes(-iNo)] is the centrifugal acceleration:

$$-i\beta\omega r\mathbf{n};$$

d) Acceleration of polar negation of affirmation (-iNoYes) is the centrifugal acceleration:

$$-i\omega\beta r\mathbf{n};$$

e) The sum of accelerations (c) and (d) defines the transverse kinetic Coriolis acceleration:

$$2\omega\beta ri\boldsymbol{\tau} \text{ or } 2\omega u_r i\boldsymbol{\tau};$$

f) Non-uniformity of motions defined by normal and tangential accelerations:

$$-\varepsilon r\mathbf{n}i + i\eta r\boldsymbol{\tau}.$$

8.4. *A structure of kinema and its moments; specific accelerations*

Based on the acceleration formulae, we obtain the formula of the potential-kinetic kinema in spiral motion

$$\hat{\mathbf{F}} = \mathbf{F}_p + \mathbf{F}_k. \tag{2.194}$$

Potential and kinetic components of the kinema are as follows:

$$\mathbf{F}_p = m(\eta + \beta^2 - \omega^2)r\mathbf{n} + m(\varepsilon + 2\omega\beta)r\boldsymbol{\tau} \tag{2.194a}$$

$$\mathbf{F}_k = m(-\varepsilon - 2\beta\omega)ir\mathbf{n} + m(\eta + \beta^2 - \omega^2)ir\boldsymbol{\tau}. \tag{2.194b}$$

The potential-kinetic specific acceleration repeats the structure of linear acceleration (2.193):

$$\hat{\varepsilon} = \varepsilon_p + \varepsilon_k, \tag{2.195}$$

where

$$\varepsilon_p = (\eta + \beta^2 - \omega^2)\mathbf{n} + (\varepsilon + 2\beta\omega)\boldsymbol{\tau} \tag{2.195a}$$

$$\varepsilon_k = (-\varepsilon - 2\beta\omega)i\mathbf{n} + (\eta + \beta^2 - \omega^2)i\boldsymbol{\tau} \tag{2.195b}$$

The potential-kinetic longitudinal-transverse moment of kinema

$$\hat{\mathbf{M}} = \mathbf{M}_n + \mathbf{M}_\tau = J\hat{\varepsilon}, \tag{2.196}$$

where

$$\mathbf{M}_n = J(\eta + \beta^2 - \omega^2 - i\varepsilon - 2i\beta\omega)\mathbf{n}, \quad (2.196a)$$

$$\mathbf{M}_\tau = J(\eta + \beta^2 - \omega^2 - i\varepsilon - 2i\beta\omega)i\boldsymbol{\tau}. \quad (2.196b)$$

repeats the structure of specific acceleration.

The axial moment of the kinema is

$$\hat{\mathbf{M}}_0 = \hat{M}\mathbf{k} = J\hat{\varepsilon}_0\mathbf{k}, \quad (2.197)$$

where

$$\hat{\varepsilon}_0 = (\eta + \beta^2 - \omega^2) - (\varepsilon + 2\beta\omega)i \quad (2.197a)$$

is the axial specific acceleration of rest.

The scalar component of the axial moment is determined within the sign. Now it is difficult to say what signs nature chooses and when. The general formulae of moments:

$$\hat{\mathbf{M}}_n = M\mathbf{n}, \quad \hat{\mathbf{M}}_\tau = -iM\boldsymbol{\tau}, \quad \hat{\mathbf{M}}_0 = \pm M\mathbf{k} \quad (2.198)$$

show that their moduli are equal.

Instantaneous specific accelerations relative to the tangent to a spiral are

$$\hat{\varepsilon}_\rho = \varepsilon_{\rho p} + \varepsilon_{\rho k}, \quad (2.199)$$

where

$$\varepsilon_p = \left[(\eta + \beta^2 - \omega^2)\mathbf{n} + (\varepsilon + 2\beta\omega)\boldsymbol{\tau}\right] / \sqrt{1+\beta^2}, \quad (2.199a)$$

$$\varepsilon_k = \left[-(\varepsilon + 2\beta\omega)i\mathbf{n} + (\eta + \beta^2 - \omega^2)i\boldsymbol{\tau}\right] / \sqrt{1+\beta^2}. \quad (2.199b)$$

Potential-kinetic moment of kinema corresponding to the instantaneous accelerations is

$$\hat{\mathbf{M}} = m\rho^2\hat{\varepsilon}_\rho = J_\rho\hat{\varepsilon}_\rho. \quad (2.200)$$

8.5. *An axial field of spiral displacement*

If the center of circular motion moves with the velocity v $_0$, the sum of the fields of motion along the axis and circular motion results in a rather complicated field of spiral motion. The axial field of spiral displacement is a field of rest-motion with the linear velocity

$$\hat{\upsilon} = \left[\upsilon_0\mathbf{k} + (-\upsilon_0 i)\mathbf{k}\right] + \omega a i\mathbf{k}, \quad (2.201)$$

The first component of the velocity in square brackets describes the axial motion-rest and the second, the circular motion. Hence, we have the expression for specific velocity of the axial field:

$$\hat{\omega} = \left[\omega_0\mathbf{k} + (-\omega_0 i)\mathbf{n}\right] + \omega i\mathbf{k}, \quad (2.202)$$

where $\omega_0 = \upsilon_0 / a$ is specific axial velocity.
From (2.202) we find the momentum, kinematic charge, and the moment of

$$\hat{\mathbf{P}} = \left[m\upsilon_0\mathbf{k} + (-m\upsilon_0 i)\mathbf{n}\right] + m\omega a i\mathbf{k}\ , \tag{2.203}$$

$$\hat{\mathbf{Q}} = \left[m\omega_0\mathbf{k} + (-m\omega_0 i)\mathbf{n}\right] + m\omega i\mathbf{k}\ , \tag{2.204}$$

$$\hat{\mathbf{L}} = \left[m\upsilon_0 a\mathbf{k} + (-m\upsilon_0 a i)\mathbf{n}\right] + J\omega i\mathbf{k}\ . \tag{2.205}$$

8.6. *Moment of momentum for an axial Geld of spiral motion*

Now, we will go back to the moment of momentum of the axial spiral field. Its potential component associated with circular motion can be expressed by

$$\mathbf{L}_p = J\omega i\mathbf{k} = \frac{2m}{T}\pi a^2\mathbf{k} = iI_m S\mathbf{k}\ . \tag{2.206}$$

The vector

$$\mathbf{P}_{mp} = iI_m S\mathbf{k} \tag{2.207}$$

will be called a potential moment of current of mass .

The vector of the current moment is generated by the axial potential momentum

$$\mathbf{P}_p = m\upsilon_p = m\omega a\mathbf{k}\ . \tag{2.208}$$

Using the appropriate component from (2.205), an additional axial kinetic moment of mass current will be expressed in terms of the potential moment:

$$\mathbf{P}_{mp} = \frac{\upsilon_0}{\upsilon_p} iI_m S\mathbf{k}\ , \tag{2.209}$$

where $\upsilon_p = \omega a$ is the potential velocity modulus. It is also a kinetic circular velocity modulus. Kinetic and potential axial charges are interrelated in a similar way:

8.7. *A description of any physical motion by a triad of rest-motion fields*

The field structure in circular and rectilinear motion is universe. Consequently, harmonic oscillations of a material point should be supplemented with a transverse field of rest, the potential velocity of which changes in the same phase with kinetic velocity of oscillations, while the potential velocity of the longitudinal field has 90° phase shift.

Any physical motion of informal structure can be expressed as superposition of elementary harmonic motions. Therefore, any real displacement of a material point in space should be described by at least the triad of a transverse field of rest $P\mathbf{n}$ and axial fields of motion $K\boldsymbol{\tau}$ and rest $P\boldsymbol{\tau}$:

$$\Pi = (P\mathbf{n}; K\boldsymbol{\tau}, P\boldsymbol{\tau})\ . \tag{2.212}$$

In harmonic motion when the displacement is

$$\hat{\Psi} = a\cos\omega t + ia\sin\omega t\ ,$$

the triad of the rest-motion field on the level of displacements, velocities, and accelerations has the following form

$$\hat{S} = (a \sin \omega t;\ ia \sin \omega t,\ a \cos \omega t)\,, \tag{2.213}$$

$$\hat{\upsilon} = (-ia\omega \sin \omega t; -a\omega \sin \omega t, ia\omega \cos \omega t)\,, \tag{2.214}$$

$$w = (-ia\omega^2 \cos \omega t;\ -a\omega^2 \cos \omega t,\ -ia\omega^2 \sin \omega t)\,. \tag{2.215}$$

With high probability it is possible to state that the axial field of rest in Microcosm and Cosmos is also negated by the own transverse kinetic field, because in the World one can observe only circular motion in a broad sense.