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Theoretical studies of Fourier telescopy for deep space imaging.

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1. Introduction.

In paper [1] it was shown, that if to illuminate a target by a pair of coherent emitters, the total reflected energy is proportional with the Fourier – component of the target's image on spatial frequency, proportional with position vector between emitters. Using many emitters located as a square matrix, and measuring a total reflected energy from each pair, it is possible to receive a good many the Fourier – components and by inverse Fourier transform to restore the image of the target. In the same paper the method of phase closure was offered to eliminate unknowns initial phases of emitters and to save the problem of their phasing. This method of imaging of remote objects was named Fourier -telescopy. In further papers [2-6] this method was more deeply studied and was perfected. However there was a series of the not solved problems rather essential to understanding of the Fourier - telescopy method. It is following problems:

As the total reflected energy cannot be received, what happens at reception of a part of reflected energy, what requirements to a size of the receiving aperture?

How does one optimally arrange emitters, that it was possible to implement a method of phase closure and to receive the greatest number the Fourier - components at minimum number of emitters?

How do a partial coherence, frequency drift and not stability of illumination have influence on Fourier-telescopy process.

What quality the image may be obtained by the Fourier - telescopy, what is its contrast, speckle structure, resolution of details?

These problems are investigated in the present paper and the some answers are obtained.

2. Statistical model of a field in the Fourier – telescopy including micro roughness of object.

In the present section there is calculated the field on the receiving aperture. It is taken into account relief and micro roughness of the surface of the object.

Let emitters are located in points $\vec{\rho}_0, \vec{\rho}_1, \ldots, \vec{\rho}_N$. Let's designate:

$\vec{R}$ is the position vector of some central point of the target, from which we digitize a position vector $\vec{r}_\Sigma$ of surface Σ;

$\vec{n} = \dfrac{\vec{R}}{R}$ is the unit vector of a direction on target, $\vec{q} = -\vec{n}$ is the unit vector of the direction from target on receiving - transmitting position (fig. 1). The field of the n – th emitter in a point $\vec{r}_\Sigma$ of surface of the target is equal

$$u_n(\vec{r}_\Sigma, i\omega) \approx \frac{ike^{-ik\left|\vec{R}+\vec{r}_\Sigma-\vec{\rho}_n\right|}}{2\pi R} g_n(\vec{\nu}_\Sigma) u_n(i\omega),$$

where $g_n(\vec{\nu}_\Sigma) = \int\limits_{A_t} e^{-ik\vec{\nu}_\Sigma\vec{\rho}} A_n(\vec{\rho}) d\vec{\rho}$ is a directivity diagram of an emitter,

$A_n(\vec{\rho})$ is the field in aperture of an emitter, $\vec{\nu}_\Sigma = \dfrac{\vec{R}+\vec{r}_\Sigma}{\left|\vec{R}+\vec{r}_\Sigma\right|}$ is the unit vector of a direction in a point $\vec{r}_\Sigma$ of surface of the target, $u_n(i\omega)$ is a spectrum of a signal, emitted by n – th emitter. The composite field of all emitters is equal

$$u_t(\vec{r}, i\omega) \approx \sum_{n=0}^{N} \frac{ike^{-ik\left|\vec{R}+\vec{r}_\Sigma-\vec{\rho}_n\right|}}{2\pi R} g_n(\vec{\nu}_\Sigma) u_n(i\omega). \qquad (2.1)$$

Further we suppose, that all emitters are focussed on the target and consequently the directivity diagrams $g_n(\vec{\nu}_\Sigma)$ are identical: $g_n(\vec{\nu}_\Sigma) = g(\vec{\nu}_\Sigma)$.

The field (2.1) is reflected by extended object with surface Σ, on which the coefficient of reflectivity $K(\vec{r}_\Sigma)$ is distributed. The reflected field in a point $\vec{\rho}$ of the receiving aperture is equal:

$$u_r(\vec{r},i\omega)=\frac{ik}{2\pi}\frac{1}{2}\int_\Sigma \frac{e^{-ik\left|\vec{\rho}-\vec{R}-\vec{r}_\Sigma\right|}}{R}(\vec{q}\vec{n}_\Sigma)K(\vec{r}_\Sigma)u_t(\vec{r}_\Sigma,i\omega)d\Sigma\,, \qquad (2.2)$$

where $\vec{n}_\Sigma$ is the unit vector of a normal line to surface of the target in a point $\vec{r}_\Sigma$.

Substituting (2.1) in (2.2), we obtain:

$$u_r(\vec{\rho},i\omega)=\left(\frac{ik}{2\pi}\right)^2\frac{1}{2}\sum_{n=0}^{N}\int_\Sigma \frac{e^{-ik\left|\vec{\rho}-\vec{R}-\vec{r}_\Sigma\right|-ik\left|\vec{R}+\vec{r}_\Sigma-\vec{\rho}_n\right|}}{R^2}\times$$

$$\times(\vec{q}\vec{n}_\Sigma)K(\vec{r}_\Sigma)g(\vec{\nu}_\Sigma)u_n(i\omega)d\Sigma\,. \qquad (2.3)$$

The obtained formula is assume for further reviewing.

We use model of a rough surface as enough smooth underlying surface, on which the roughnesses are overlapped:

$$\vec{r}_\Sigma=\vec{r}+\vec{N}\xi(\vec{r}), \qquad (2.4)$$

where $\vec{r}_\Sigma$ is a position vector of rough surface, $\vec{r}$ is a position vector of underlying surface, $\vec{N}$ is a unit vector of a normal line to underlying surface, $\xi(\vec{r})$ is height of roughness above underlying surface (fig. 2). We suppose, that the field $\xi(\vec{r})$ represents homogeneous on a underlying surface random field with zero expectation and correlation function $\overline{\xi(\vec{r}_1)\xi(\vec{r}_2)}=B(\vec{r}_1,\vec{r}_2)$. The homogeneity means, that $B(\vec{r}_1,\vec{r}_2)=B\big(l(\vec{r}_1,\vec{r}_2)\big)$, where $l(\vec{r}_1,\vec{r}_2)$ is a distance between points $\vec{r}_1$, $\vec{r}_2$ on a underlying surface.

Let's substitute (2.4) in (2.3) and use paraxial approximation, taking into account, that $R>>\rho, r, \rho_n$, i.e. sizes of target, matrixes of emitters and receiving aperture are small in comparison with distance up to the target. Received field in point $\vec{\rho}$ of receiving aperture can be noted as:

$$u_r(\vec{\rho},i\omega)=\frac{-1}{2\lambda^2R^2}e^{-2ikR}\sum_{n=0}^{N}\int_S e^{-ik\frac{|\vec{r}_\perp-\vec{\rho}_n|^2+|\vec{\rho}-\vec{r}_\perp|^2}{2R}+2ik\left(\rho_q+\rho_{nq}+r_q-N_q\xi(\vec{r})\right)}\times$$

$$\times\left(1-\frac{\nabla_q\xi(\vec{r})}{N_q}\right)K(\vec{r})g\left(\frac{\vec{r}_\perp}{R}\right)N_q dS\cdot u_n(i\omega),\qquad(2.5)$$

where $r_q=\vec{q}\vec{r}$, $\rho_q=\vec{q}\vec{\rho}$, $\rho_{nq}=\vec{q}\vec{\rho}_n$ are projections of vectors $\vec{r}$, $\vec{\rho}$, $\vec{\rho}_n$ on direction $\vec{q}$,

$\vec{r}_\perp=\vec{r}-\vec{q}(\vec{q}\vec{r})$ is perpendicular to $\vec{q}$ component of vector $\vec{r}$,

$\nabla_q\xi(\vec{r})=\vec{q}\nabla\xi(\vec{r})$, $\nabla\xi(\vec{r})=\vec{\mu}\frac{\partial\xi(\vec{r})}{\partial u}+\vec{\nu}\frac{\partial\xi(\vec{r})}{\partial v}$, u,v are local orthogonal coordinates on a underlying surface in an environ to a point $\vec{r}$, $\vec{\mu},\vec{\nu}$ are basis vectors of coordinate axises.

In a temporal aspect the field (2.5) is look like:

$$u_r(\vec{\rho},t)\sim 2\operatorname{Re}\int_{\omega_0\pm\Delta\omega}u_t(\vec{\rho},i\omega)e^{i\omega t}d\omega=2\operatorname{Re}e^{i\omega_0 t}U(\vec{\rho},t),$$

where the complex amplitude of received field is equal

$$U(\vec{\rho},t)\approx\frac{-1}{2\lambda^2R^2}e^{-2ikR}\sum_{n=0}^{N}\int_S e^{-ik\frac{|\vec{r}_\perp-\vec{\rho}_n|^2+|\vec{\rho}-\vec{r}_\perp|^2}{2R}+2ik\left(\rho_q+\rho_{nq}+r_q-N_q\xi(\vec{r})\right)}\times$$

$$\times\left(1-\frac{\nabla_q\xi(\vec{r})}{N_q}\right)K(\vec{r})g\left(\frac{\vec{r}_\perp}{R}\right)U_n\left[t-\frac{2R}{c}-\frac{2\left(\rho_q+\rho_{nq}+r_q\right)}{c}\right]N_q dS.\qquad(2.6)$$

Here $U_n(t)$ is complex envelope of a signal illuminated by $n-$th emitter. As it is slow function, we have neglected delays on rather small times $\frac{|\vec{r}_\perp-\vec{\rho}_n|^2+|\vec{\rho}-\vec{r}_\perp|^2}{2Rc}+\frac{2N_q\xi(\vec{r})}{c}$. The delays on times $\frac{2(\rho_q+\vec{\rho}_{nq})}{c}$ vanish, if the target is on a vertical (we consider the emitters are located in a horizontal plane). However, if the target is not on a vertical, there are additional increments of optical path from different emitters up to the target and from the target up to different points of the receiving aperture at the inclination of a sighting line. Let's while suppose signals of emitters high-stable to neglect delays complex envelope on times $\frac{2(\rho_q + \rho_{nq} + r_q)}{c}$. Consequently, we have:

$$U_r(\vec{\rho},t) \approx \frac{-1}{2\lambda^2 R^2} e^{-2ikR} \sum_{n=0}^{N} U_n(t') \int_S e^{-ik\frac{|\vec{r}_\perp - \vec{\rho}_n|^2 + |\vec{\rho} - \vec{r}_\perp|^2}{2R} + 2ik(\rho_q + \rho_{nq} + r_q - N_q \xi(\vec{r}))} \times$$

$$\times \left(1 - \frac{\nabla_q \xi(\vec{r})}{N_q}\right) K(\vec{r}) g\left(\frac{\vec{r}_\perp}{R}\right) N_q dS, \qquad (2.7)$$

Where $t' = t - \frac{R}{c}$.

3. Reception and processing of a reflected field.

In the present section the reception and processing of a field $U_r(\vec{\rho},t)$ (2.7), ended by deriving of input data for elimination of unknowns of phases by the phase closure method, deriving the Fourier – components and forming the image is considered. We presume, that the amplitudes $U_n(t)$ in (2.7) have personal frequency coloring: $U_n(t) \to U_n(t) e^{i\Delta\omega_n t}$, all differences $\Delta\omega_n - \Delta\omega_m$ are various, also bandwidth of signals $U_n(t)$ $\Delta\omega << |\Delta\omega_n - \Delta\omega_m|$. The field $U_r(\vec{\rho},t)$ transits an optical filter, is detected, after detected signal transits a system of filters tuned on frequencies $\Delta\omega_n - \Delta\omega_m$, and after phase detector we obtain primary signals $X_{mn}(t)$.

In [10] the problem of choice of frequencies $\Delta\omega_m$ surveyed, that all differences $\Delta\omega_n - \Delta\omega_m$, $n,m = 0...N$, were various. For basis takes minimum discrete $\Delta\omega$ and the frequencies are searched as: $\Delta\omega_m = c(m)\Delta\omega$. For $N=30$, for example, the following outcomes are obtained:

Table 1.

m	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$c(m)$	0	1	3	7	12	20	30	44	59	75	96	118	143	169	197	230

m	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
$c(m)$	264	299	335	373	413	455	501	549	598	648	701	758	818	880	944

For approximated estimations it is possible to note, that $c(m) \sim m^2$.

In outcome of photo detecting the receiver measures power of a field (2.7) passed over the receiving aperture A:

$$P(t) = \frac{1}{4\lambda^4 R^4} \sum_{m,n=1}^{N} U_m(t')U_n^*(t') e^{i(\Delta\omega_n - \Delta\omega_m)t' - ik\frac{\rho_m^2 - \rho_n^2}{2R} + 2ik(\rho_{nq} - \rho_{mq})} \times \quad (3.1)$$

$$) \times \int_S\int_S e^{-ik\frac{r_{\perp 1}^2 - r_{\perp 2}^2}{R} + ik\frac{(\vec{\rho}_m \vec{r}_{\perp 1} - \vec{\rho}_n \vec{r}_{\perp 2})}{R}} u(\vec{r}_{\perp 1} - \vec{r}_{\perp 2}) e^{2ik\left[\left(r_{q1} - N_{q1}\xi(\vec{r}_1)\right) - \left(r_{q2} - N_{q2}\xi(\vec{r}_2)\right)\right]} \times$$

$$\times \left(1 - \frac{\nabla_q \xi(\vec{r}_1)}{N_{q1}}\right)\left(1 - \frac{\nabla_q \xi(\vec{r}_2)}{N_{q2}}\right) K(\vec{r}_1)K^*(\vec{r}_2) g\left(\frac{\vec{r}_{\perp 1}}{R}\right) g^*\left(\frac{\vec{r}_{\perp 2}}{R}\right) N_{q1}N_{q2} dS_1 dS_2$$

where
$$u(\vec{r}_\perp) = \int_A e^{ik\frac{\vec{r}_\perp \vec{\rho}}{R}} d\vec{\rho} \quad (3.2)$$

is a point spread function of the aperture A.

Passing the signal (3.1) through a system of filters, tuned on frequencies $\Delta\omega_m - \Delta\omega_n$ and realizing phase detection, we can separately select complex amplitudes

$$X_{mn}(t) = U_m(t')U_n^*(t') e^{-ik\frac{\rho_m^2 - \rho_n^2}{2R} + 2ik(\rho_{qn} - \rho_{qm})} F_{mn}, \quad (3.3)$$

where
$$F_{mn} = \int_{S_\perp}\int_{S_\perp} e^{-ik\frac{r_{\perp 1}^2 - r_{\perp 2}^2}{R} + ik\frac{(\vec{\rho}_m \vec{r}_{\perp 1} - \vec{\rho}_n \vec{r}_{\perp 2})}{R}} u(\vec{r}_{\perp 1} - \vec{r}_{\perp 2}) \times$$

$$\times\left(1-\frac{\nabla_q\xi(\vec{r}_1)}{N_{q1}}\right)\left(1-\frac{\nabla_q\xi(\vec{r}_2)}{N_{q2}}\right)e^{2ik\left[\left(r_{q1}-N_{q1}\xi(\vec{r}_1)\right)-\left(r_{q2}-N_{q2}\xi(\vec{r}_2)\right)\right]}\times$$

$$\times K(\vec{r}_1)K^*(\vec{r}_2)g\left(\frac{\vec{r}_{\perp 1}}{R}\right)g^*\left(\frac{\vec{r}_{\perp 2}}{R}\right)d\vec{r}_{\perp 1}d\vec{r}_{\perp 2}. \qquad (3.4)$$

Here is used $N_q dS = d\vec{r}_\perp$, and $S_\perp$ is silhouette of the target in a plane $\vec{r}_\perp$ (perpendicular target sighting line).

The signals $X_{mn}(t)$ are result of primary processing of a field. The further transformations are bound with digitization of signals $X_{mn}(t)$ and computer processing. A first step is the procedure of phase closure and elimination of factors $U_m(t')U_n^*(t')e^{-ik\frac{\rho_m^2-\rho_n^2}{2R}+2ik(\rho_{nq}-\rho_{mq})}$, containing unknowns phases. In outcome the magnitudes F_{mn} (3.4) will be chosen in the pure state. The first idea of the Fourier - telescopy encompassed that the magnitudes F_{mn} are the Fourier – components of the image of the target. In particular, it takes place at the rather large receiving aperture. However from the formula (3.4) is not seen immediately Fourier transforms and image of the target. Therefore principal problem is the study of requirements, when (3.4) transmutes in a Fourier transform of some image and study of properties of this image.

4. Case of the rather large receiving aperture.

The idea of the Fourier – telescopy method consists that at the very large receiving aperture A

$$u(\vec{r}_{\perp 1}-\vec{r}_{\perp 2})\approx\left(\frac{2\pi R}{k}\right)^2\delta(\vec{r}_{\perp 1}-\vec{r}_{\perp 2}). \qquad (4.1)$$

Thus is gave:

$$F_{mn}=\lambda^2R^2\int_{S_\perp}e^{ik\frac{(\vec{\rho}_m-\vec{\rho}_n)\vec{r}_\perp}{R}}\left(1-\frac{\nabla_q\xi(\vec{r})}{N_q}\right)^2\left|K(\vec{r})\right|^2\left|g\left(\frac{\vec{r}_\perp}{R}\right)\right|^2d\vec{r}_\perp=$$

$$=\lambda^2 R^2 F^*\left(\frac{k(\vec{\rho}_m-\vec{\rho}_n)}{R}\right), \quad (4.2)$$

i.e. F_{mn} there is a Fourier transform of function

$$I_1(\vec{r}_\perp)=\left(1-\frac{\nabla_q\xi(\vec{r})}{N_q}\right)^2 |K(\vec{r})|^2\left|g\left(\frac{\vec{r}_\perp}{R}\right)\right|^2, \quad (4.3)$$

on frequency $\vec{f}_{mn}=\frac{k(\vec{\rho}_m-\vec{\rho}_n)}{R}$. The function $I_1(\vec{r}_\perp)$ is some optical image of the target. This image depends on a reflection factor $|K(\vec{r})|^2$, intensity illumination $\left|g\left(\frac{\vec{r}_\perp}{R}\right)\right|^2$, and from geometry of a surface of the target $\left(1-\frac{\nabla_q\xi(\vec{r})}{N_q}\right)^2$. Due to dependence from micro roughness $\xi(\vec{r})$ this image is random, that should be exhibited in it spekleness. However this dependence is faint, as it is usual a steepness of micro roughnesses are small enough, and $\frac{\nabla_q\xi(\vec{r})}{N_q}<<1$. Neglecting $\frac{\nabla_q\xi(\vec{r})}{N_q}$, we shall receive:

$$I_1(\vec{r}_\perp)=|K(\vec{r})|^2\left|g\left(\frac{\vec{r}_\perp}{R}\right)\right|^2. \quad (4.4)$$

This image does not depend at all on geometry of a surface of the target.

Let's clarify now as far as be great the aperture A owes, that $u(\vec{r}_{\perp 1}-\vec{r}_{\perp 2})$ it was possible to consider $\delta-$ figurative in relation to function under the sign of integral in (3.4). Let's mark, that length of the spike of function $u(\vec{r}_{\perp 1}-\vec{r}_{\perp 2})$ has the order $\frac{\lambda R}{\sqrt{A}}$, where $\sqrt{A}-$ diameter of the receiving aperture.. Most quickly changed factor under an integral (3.4) is $e^{2ik[(r_{q1}-N_{q1}\xi(\vec{r}_1))-(r_{q2}-N_{q2}\xi(\vec{r}_2))]}$. That this function did not vary on an length

$\sim \frac{\lambda R}{\sqrt{A}}$, it is necessary to have $\sqrt{A} >> k_S R$, $\sqrt{A} >> k_\xi R$, where k_S, k_ξ are characteristic steepness of a underlying surface and, accordingly, of micro roughness. At characteristic steepness of roughness about 0.1 [7] it reduces in silly large values of diameter of the receiving aperture (at $R \sim 10\,km$ $\sqrt{A} >> 1\,km$; At $R \sim 40000\,km$ (geosynchronous objects) $\sqrt{A} >> 4000\,km$). It is put under doubt practical reliability of the Fourier - telescopy. However essential role in estimation can play providing for influence of micro roughness of object's surface.

5. Consideration of deriving of distortionless Fourier coefficients of the micro rough target image.

Generally, as was already marked, the quantities F_{mn} are not the Fourier coefficients of any target image , and have a complex form (3.4). As into the formula (3.4) go into a micro unevenness $\xi(\vec{r})$, quantities F_{mn} are random. Therefore it is necessary to study statistical properties of quantities F_{mn} and to clarify, when they become look like the Fourier coefficients of a image of the target, and which image.

Let's calculate statistical characteristics of quantities F_{mn} (3.4), suggesting $\xi(\vec{r})$ by a homogeneous field on underlying surface. Let's mark, that for such field $\xi(\vec{r})$ and $\nabla\xi(\vec{r})$ independent. Therefore

$$\langle F_{mn}\rangle = \int_{S_\perp}\int_{S_\perp} e^{-ik\frac{r_{\perp1}^2 - r_{\perp2}^2}{R} + ik\frac{(\vec{\rho}_m \vec{r}_{\perp1} - \vec{\rho}_n \vec{r}_{\perp2})}{R}} u(\vec{r}_{\perp1} - \vec{r}_{\perp2}) \times$$

$$\times \left\langle \left(1 - \frac{\nabla_q \xi(\vec{r}_1)}{N_{q1}}\right)\left(1 - \frac{\nabla_q \xi(\vec{r}_2)}{N_{q2}}\right)\right\rangle \left\langle e^{2ik\left[\left(r_{q1} - N_{q1}\xi(\vec{r}_1)\right) - \left(r_{q2} - N_{q2}\xi(\vec{r}_2)\right)\right]}\right\rangle \times$$

$$\times K(\vec{r}_1)K^*(\vec{r}_2) g\left(\frac{\vec{r}_{\perp1}}{R}\right) g^*\left(\frac{\vec{r}_{\perp2}}{R}\right) d\vec{r}_{\perp1} d\vec{r}_{\perp2}. \qquad (5.1)$$

In an Apendix it is shown, that $\left\langle e^{-2ik\left[N_{q1}\xi(\vec{r}_1)+N_{q2}\xi(\vec{r}_2)\right]}\right\rangle$ represents rather narrow peak, length of which there is an order $\sim \dfrac{\lambda l_\xi}{4\pi\sigma_\xi}$. It is possible to expect, that this peak $\delta-$ figurative in reference to all functions under the sign of integral in (5.1). The requirement of it $\delta-$ figurativeness in reference to function $e^{ik\frac{(\vec{\rho}_m\vec{r}_{\perp 1}-\vec{\rho}_n\vec{r}_{\perp 2})}{R}}$ looks like:

$$k\frac{|\vec{\rho}_m-\vec{\rho}_n|}{R}\cdot\frac{\lambda l_\xi}{4\pi\sigma_\xi}<<2\pi,\quad L_t<<4\pi\frac{\sigma_\xi}{l_\xi}R\approx R,$$

that with a major reserve is executed. Here L_t is a maximum size of a matrix of emitters. The requirement of $\delta-$ figurativeness in relation to function $e^{2ik\left(r_{q1}-r_{q2}\right)}$ gives faint limitation in a reference steepness of a underlying surface: $k_S<<2\pi\dfrac{\sigma_\xi}{l_\xi}$.

Remaining functions under the sign of integral in (5.1) are essential more slowly varied. Thus, we have:

$$\langle F_{mn}\rangle = A\int\limits_{S_\perp} e^{ik\frac{(\vec{\rho}_m-\vec{\rho}_n)\vec{r}_{\perp 1}}{R}}|K(\vec{r}_1)|^2\left|g\left(\frac{\vec{r}_{\perp 1}}{R}\right)\right|^2\times$$

$$\times\left\{\int\limits_{S_\perp}\left\langle e^{2ik\left[\left(r_{q2}-N_{q1}\xi(\vec{r}_1)\right)-\left(r_{q2}-N_{q2}\xi(\vec{r}_2)\right)\right]}\right\rangle\left\langle\left(1-\frac{\nabla_q\xi(\vec{r}_1)}{N_{q1}}\right)\left(1-\frac{\nabla_q\xi(\vec{r}_2)}{N_{q2}}\right)\right\rangle d\vec{r}_{\perp 2}\right\}d\vec{r}_{\perp 1}\approx$$

$$\approx A\frac{l_\xi^2\lambda^2}{8\pi\sigma_\xi^2}\int\limits_{S_\perp} e^{ik\frac{(\vec{\rho}_m-\vec{\rho}_n)\vec{r}_\perp}{R}}e^{-\frac{N_\perp^2}{N_q^2}\frac{l_\xi^2}{2\sigma_\xi^2}}\left(1+\frac{\sigma_\xi^2}{l_\xi^2}\frac{N_\perp^2}{N_q^2}\right)\frac{|K(\vec{r})|^2}{N_q}\left|g\left(\frac{\vec{r}_\perp}{R}\right)\right|^2 d\vec{r}_\perp\approx.$$

$$\approx A\frac{l_\xi^2\lambda^2}{8\pi\sigma_\xi^2}\int\limits_{S_\perp} e^{ik\frac{(\vec{\rho}_m-\vec{\rho}_n)\vec{r}_\perp}{R}} I_0(\vec{r}_\perp)d\vec{r}_\perp\,. \qquad (5.2)$$

We have obtained a Fourier transform of function

$$I_0(\vec{r}_\perp) = e^{-\frac{N_\perp^2}{N_q^2}\frac{l_\xi^2}{2\sigma_\xi^2}}\left(1+\frac{\sigma_\xi^2}{l_\xi^2}\frac{N_\perp^2}{N_q^2}\right)\frac{|K(\vec{r})|^2}{N_q}\left|g\left(\frac{\vec{r}_\perp}{R}\right)\right|^2. \tag{5.3}$$

As shown in [7], $I_0(\vec{r}_\perp)$ is an optical image of micro rough object, which is obtained in a natural light with the help of a standard optical instrument. Let's underline, that it differs from an image $I_1(\vec{r}_\perp)$ (5.4), obtained by a Fourier-telescope at the super-large receiving aperture.

Let's investigate now fluctuation of F_{mn}. For this purpose we calculate $\left\langle |F_{mn}|^2 \right\rangle - |\langle F_{mn}\rangle|^2$. In an Apendix the relevant evaluations are done and the following outcome is obtained:

$$\left\langle |F_{mn}|^2 \right\rangle - |\langle F_{mn}\rangle|^2 \approx \left(\frac{l_\xi^2\lambda^2}{8\pi\sigma_\xi^2}\right)^2 \int_{S_\perp}\int_{S_\perp} h(\vec{r}_{1\perp}-\vec{r}_{\perp 2}) I_0(\vec{r}_{\perp 1}) I_0(\vec{r}_{\perp 2}) d\vec{r}_{1\perp} d\vec{r}_{2\perp} \tag{5.4}$$

We should be interested with relative quantity of fluctuation of F_{mn}:

$$\eta_{mn} = \frac{\left\langle |F_{mn}|^2 \right\rangle - |\langle F_{mn}\rangle|^2}{|\langle F_{mn}\rangle|^2}.$$

Using (5.2) and (5.4), we obtain:

$$\eta_{mn} = \frac{\int_{S_\perp}\int_{S_\perp} h(\vec{r}_{\perp 1}-\vec{r}_{\perp 2}) I_0(\vec{r}_{\perp 1}) I_0(\vec{r}_{\perp 2}) d\vec{r}_{\perp 1} d\vec{r}_{\perp 2}}{A^2\left|\int_{S_\perp} e^{ik\frac{(\vec{\rho}_m-\vec{\rho}_n)\vec{r}_\perp}{R}} I_0(\vec{r}_\perp) d\vec{r}_\perp\right|^2} \tag{5.5}$$

.

For an estimation of this quantity we shall assume at first, that the aperture A is small also sizes of the target less of a resolution element $S_{tg} << \frac{\lambda^2 R^2}{A}$. In this case $h(\vec{r}_{\perp 1} - \vec{r}_{\perp 2}) \approx A^2$ and η_{mn} matters about unites.. It evidences about strong fluctuations F_{mn}, so the concrete realization of F_{mn} is random also unpredictable. Let's assume, that the aperture A is large and there are many elements of a resolution are stacked on the target:

$$M \approx \frac{S_{tg}}{\lambda^2 R^2 / A} >> 1, \qquad \text{i.e. } A >> \frac{\lambda^2 R^2}{S_{tg}}. \tag{5.6}$$

Thus $h(\vec{r}_{\perp 1} - \vec{r}_{\perp 2}) \approx R^2 \lambda^2 A \cdot \delta(\vec{r}_{\perp 1} - \vec{r}_{\perp 2})$ and we obtain:

$$\eta_{mn} = \frac{R^2 \lambda^2 \int\limits_{S_\perp} I_0^2(\vec{r}_\perp) d\vec{r}_\perp}{A \left| \int\limits_{S_\perp} e^{ik \frac{(\vec{\rho}_m - \vec{\rho}_n)\vec{r}_\perp}{R}} I_0(\vec{r}_\perp) d\vec{r}_\perp \right|^2} \tag{5.7}$$

From here it is visible, that at $A >> \frac{\lambda^2 R^2}{S_{tg}}$ $\eta_{mn} << 1$. It means, that F_{mn} practically do not fluctuate and are equaled medial: $F_{mn} \approx \langle F_{mn} \rangle$. Thus, at execution of a requirement (5.6) output signals of a Fourier-telescope F_{mn} represent Fourier-components of an image of the target, this image $I_0(\vec{\rho}_\perp)$ is expressed by the formula (5.3) and represents the usual image obtained with the help of a standard optical instrument in a natural light.

6. Reception of a field with matrix of spaced telescopes.

It was above established, that the size of the receiving aperture of a telescope for forming images should obey to usual Rayleigh measure:

$$\frac{\lambda^2 R^2}{A} >> S_{tg}\text{, or } M = \frac{S_{tg} A}{\lambda^2 R^2} >> 1,$$

where M is number of a resolution elements, stacked in square of the target. However for usual telescopes the requirement of high optical quality of a receiving mirror adds to this requirement. In the Fourier - telescopy the receiving telescope appears as a collector of an energy, and any key requirements to quality of a mirror is not showed. Therefore for the Fourier - telescopy rather actual is represented idea to synthesize the large receiving aperture from the small spaced apertures. The problem of a precise coherent bringing together of light beams from the spaced telescopes here does not exist.

Let's assume, that the illuminated power receives by K telescopes with the identical entering apertures A_0, placed on terrain in points $\vec{\vartheta}_n$, $n = 1,\dots,K$. Let's designate a pupil functions of telescopes $A(\vec{\rho} - \vec{\vartheta}_n)$. Let's note a received field (2.7) in the reduced form:

$$U_r(\vec{\rho},t) \sim \int_S e^{-ik\frac{|\vec{\rho}-\vec{r}_\perp|^2}{2R}} \boldsymbol{\Phi}(\vec{r}_\perp,t) d\vec{r}_\perp.$$

The received power is equal:

$$P(t) = \sum_{k=1}^{K} \int A(\vec{\rho} - \vec{\vartheta}_k) |U_r(\vec{\rho},t)|^2 d\vec{\rho} = \tag{6.1}$$

$$= \int_{S_\perp} \int_{S_\perp} \Phi(\vec{r}_{\perp 1},t) \Phi^*(\vec{r}_{\perp 2},t) e^{-ik\frac{r_{\perp 1}^2 - r_{\perp 2}^2}{2R}} \left\{ \sum_{k=1}^{K} \int A(\vec{\rho} - \vec{\vartheta}_k) e^{ik\frac{\vec{\rho}(\vec{r}_{\perp 1} - \vec{r}_{\perp 2})}{R}} d\vec{\rho} \right\} d\vec{r}_{\perp 1} d\vec{r}_{\perp 2} =$$

$$= \int_{S_\perp} \int_{S_\perp} \Phi(\vec{r}_{\perp 1},t) \Phi^*(\vec{r}_{\perp 2},t) e^{-ik\frac{r_{\perp 1}^2 - r_{\perp 2}^2}{2R}} u_0\left(\frac{k(\vec{r}_{\perp 1} - \vec{r}_{\perp 2})}{R} \right) G(\vec{r}_{\perp 1} - \vec{r}_{\perp 2}) d\vec{r}_{\perp 1} d\vec{r}_{\perp 2}$$

, where $u_0\left(\frac{k\vec{r}}{R}\right) = \int\limits_{A_0} e^{ik\frac{\vec{\rho}\vec{r}}{R}} d\vec{\rho}$ is a point spread function of the aperture A_0,

$G(\vec{r}) = \sum_{k=1}^{K} e^{ik\frac{\vec{r}\vec{\vartheta}_k}{R}}$ is a lattice factor of receiving telescopes. If receiving telescopes spaced in nodes of a square lattice with a pitch d_r, then

$$G(\vec{r}) = \sum_{k=1}^{K} e^{\frac{2\pi i}{L_r}\vec{r}\vec{a}_k}, \tag{6.2}$$

where $L_r = \frac{\lambda R}{d_r}$, $\vec{a}_k$ – an integer vector. The function (6.2) is periodic with a period L_r in two directions. At enough major K it looks like a narrow peak, concentrated above a site $\sigma_r = \frac{L_r^2}{K}$. The function $u_0\left(\frac{k(\vec{r}_{\perp 1} - \vec{r}_{\perp 2})}{R}\right) G(\vec{r}_{\perp 1} - \vec{r}_{\perp 2})$ is equivalent to a point spread function of the uniform major aperture A if $K = \frac{A^2}{L_r^2}$ and L_r exceeds enough size of the target (that under the sign of integral (6.1) there was only one peak of function $G(\vec{r}_{\perp 1} - \vec{r}_{\perp 2})$). Thus, if the linear size of the target is l_{tg}, having filled square A by small telescopes with distance between them $d_r < \frac{\lambda R}{l_{tg}}$ we obtain for the Fourier telescopy the same effect, as an energy is received by one major telescope with the aperture A.

7. Method of phase closure and influence of temporal unstability of illumination.

The method of phase closure allows to eliminate of unknowns initial phases of emitters and thus to save a problem of their special phasing. For implementation of a method of phase closure it is necessary, that the adjacent emitters were shifted from each other on d or on an axes x, or on an axes y (not simultaneously). The examples of configurations of matrixes of emitters are shown in a fig. 4.

Let a signal $X_{mn}(t)$ (3.3) from $m-$ th and $n-$th emitters is selected. Let's consider that $m<n$ and that path from emitter $\vec{\rho}_m$ to emitter $\vec{\rho}_n$ pass through emitters $\vec{\rho}_{m+1}, \vec{\rho}_{m+2}, ..., \vec{\rho}_{n-1}$. Simultaneously signals from neighboring emitters $X_{(k-1)k}(t)$, $k=m+1,...,n$, are received. As it was shown in Point 3 signals $X_{mn}(t)$ have form:

$$X_{mn}(t)=U_m(t')U_n^*(t')e^{-ik\frac{\rho_m^2-\rho_n^2}{2R}+2ik(\rho_{qn}-\rho_{qm})}F_{mn},$$

where F_{mn} are expressed by the formulas (3.4) and under particular requirements represent Fourier transforms of the image of the target. The phase closure method consists in a multiplication of all $\dfrac{X_{(k-1)k}(t)}{\left|X_{(k-1)k}(t)\right|}$, $k=m+1,..., n,$ and closing of the obtaining product by multiplication on $X_{mn}^*(t)$. Thus is obtained

$$Y_{mn}(t)=\prod_{k=m+1}^{n}\frac{X_{(k-1)k}(t)}{\left|X_{(k-1)k}(t)\right|}\cdot X_{mn}^*=$$

$$=\left|U_m(t')U_n^*(t')\right|e^{-i\sum\limits_{k=m+1}^{n}\Phi\left(\frac{2\pi}{L}(\vec{a}_k-\vec{a}_{k-1})\right)}F\left(\frac{2\pi}{L}(\vec{a}_m-\vec{a}_n)\right).$$

After temporary smoothing we obtain:

$$Y_{mn}=\int Y_{mn}(t)dt=V_{mn}e^{-i\sum\limits_{k=m+1}^{n}\Phi\left(\frac{2\pi}{L}(\vec{a}_k-\vec{a}_{k-1})\right)}F\left(\frac{2\pi}{L}(\vec{a}_m-\vec{a}_n)\right), \quad (7.1)$$

where $$\Phi(\vec{f})=\arg F(\vec{f}), \quad V_{mn}=\int\left|U_m(t')U_n^*(t')\right|dt. \quad (7.2)$$

As $\vec{a}_k - \vec{a}_{k-1} = (\pm 1,0)$ or $(0,\pm 1)$ only two phases $\alpha = \mathbf{\Phi}\left(\frac{2\pi}{L},0\right)$, $\beta = \mathbf{\Phi}\left(0,\frac{2\pi}{L}\right)$ are presence in expression (7.1). Let's assume $\vec{\gamma} = (\alpha, \beta)$. It is easy to see, that

$$\sum_{k=m+1}^{n} \mathbf{\Phi}\left(\frac{2\pi}{L}(\vec{a}_k - \vec{a}_{k-1})\right) = \vec{\gamma}(\vec{a}_m - \vec{a}_n). \tag{7.3}$$

From obtained expressions follows:

$$Y_{mn} = V_{mn} e^{-i\vec{\gamma}(\vec{a}_m - \vec{a}_n)} F\left(\frac{2\pi}{L}(\vec{a}_m - \vec{a}_n)\right) \tag{7.4}$$

If to put $V_{mn} = V = const$, the quantities Y_{mn} represent in the pure state Fourier-components with a phase, proportional frequency. At image reconstruction we receive:

$$\widetilde{I}(\vec{r}_\perp) = \frac{1}{L^2} \sum_{\vec{p}} F\left(\frac{2\pi\vec{p}}{L}\right) e^{\frac{2\pi i}{L}\vec{p}(\vec{r}_\perp - \vec{\gamma})} = I(\vec{r}_\perp - \vec{\gamma}). \tag{7.5}$$

Thus, the restored image appears shifted on a vector $\vec{\gamma}$, that is unessential for the research of an inner pattern problems and of the image recognition.

It is essential to mark, that as a result of phase closure phase fluctuations of signals were purely eliminated. It is valid for high-stable signals, space length of which is well exceed the size of target. In particular it relate to chirp with parameters $10\, MHz/\mu\sec$.

As it is visible from expression (7.4), amplitude fluctuations of a signal at phase closure completely are not cancelled, that is exhibited available of random factors V_{mn} at the Fourier coefficients. However in a case $\tau_i \Delta f >> 1$, where τ_i is a illumination pulse duration, the temporal smoothing is equivalent to a statistical average and we obtain: $V_{mn} \approx \langle V_{mn} \rangle \approx const$, i.e. the amplitude stability does not influence on the Fourier - telescopy process.

Generally in case of partial coherent signals the output signals $X_{mn}(t)$, obtained by Fourier-telescope, will look like:

$$X_{mn}(t)=\widetilde{U}_m(t')\widetilde{U}_n(t')e^{-ik\frac{\rho_m^2-\rho_n^2}{2R}+2ik(\rho_{qn}-\rho_{qm})}F_{mn}(t),$$

Where $F_{mn}(t)=\int\limits_{S_\perp}\int\limits_{S_\perp} e^{-ik\frac{r_{\perp1}^2-r_{\perp2}^2}{R}+ik\frac{(\vec{\rho}_m\vec{r}_{\perp1}-\vec{\rho}_n\vec{r}_{\perp2})}{R}}u(\vec{r}_{\perp1}-\vec{r}_{\perp2})\times$

$$\times\left(1-\frac{\nabla_q\xi(\vec{r}_1)}{N_{q1}}\right)\left(1-\frac{\nabla_q\xi(\vec{r}_2)}{N_{q2}}\right)e^{2ik\left[\left(r_{q1}-N_{q1}\xi(\vec{r}_1)\right)-\left(r_{q2}-N_{q2}\xi(\vec{r}_2)\right)\right]}\times$$

$$\times v_m\left[t'-\frac{2\left(\rho_q+\rho_{nq}+r_{q1}\right)}{c}\right]v_n^*\left[t'-\frac{2\left(\rho_q+\rho_{mq}+r_{q2}\right)}{c}\right]\times$$

$$\times K(\vec{r}_1)K^*(\vec{r}_2)g\left(\frac{\vec{r}_{\perp1}}{R}\right)g^*\left(\frac{\vec{r}_{\perp2}}{R}\right)d\vec{r}_{\perp1}d\vec{r}_{\perp2}. \quad (7.6)$$

Here functions $\widetilde{U}_m(t')$ represent a slow part of amplitude $U_m(t')$, and $v_m\left(t'-\frac{2\left(\rho_q+\rho_{nq}+r_{q1}\right)}{c}\right)$ – quick fluctuations . Usually $v(t)$ approximate by stationary stochastic process with time of correlation τ. Thus $l_c=\frac{c\tau}{2}$ there is a length of a coherence of illumination.

The functions $v_m\left[t'-\frac{2\left(\rho_q+\rho_{nq}+r_{q1}\right)}{c}\right]$ and $v_n^*\left[t'-\frac{2\left(\rho_q+\rho_{mq}+r_{q2}\right)}{c}\right]$ cannot be taken out from under the sign of an integral because of presence of a delay $\frac{2r_q}{c}$. Most important in the practical ration there is the case, when $\Delta f_0\tau>>1$, where Δf_0 is a bandwidth of filters selecting frequency ω_{mn}. Thus the smoothing realized after phase detection, practically will reduce to average of a signal. If the signals, emitted different emitters are independent, we receive: $\overline{v_m(t_1)v_n(t_2)}\approx\overline{v_m(t_1)}\cdot\overline{v_n(t_2)}=0$. From here follows, that between signals emitted by the different emitters, rigid correlation should exist. It is possible in case the emitters feed from one generator and the optical paths from the generator to emitters are sustained identical within the accuracy of lengths of a coherence of the generator. Thus we have: $v_m(t)\approx v_n(t)=v(t)$ also we obtain:

$$F_{mn}(t)\approx\overline{F_{mn}(t)}=\int_{S_\perp}\int_{S_\perp} e^{-ik\frac{r_{\perp 1}^2-r_{\perp 2}^2}{R}+ik\frac{(\vec{\rho}_m\vec{r}_{\perp 1}-\vec{\rho}_n\vec{r}_{\perp 2})}{R}} u(\vec{r}_{\perp 1}-\vec{r}_{\perp 2})\times$$

$$\times\left(1-\frac{\nabla_q\xi(\vec{r}_1)}{N_{q1}}\right)\left(1-\frac{\nabla_q\xi(\vec{r}_2)}{N_{q2}}\right)e^{2ik\left[\left(r_{q1}-N_{q1}\xi(\vec{r}_1)\right)-\left(r_{q2}-N_{q2}\xi(\vec{r}_2)\right)\right]}\times$$

$$\times\overline{v_m\left[t'-\frac{2\left(\rho_q+\rho_{nq}+r_{q1}\right)}{c}\right]v_n^*\left[t'-\frac{2\left(\rho_q+\rho_{mq}+r_{q2}\right)}{c}\right]}\times$$

$$\times K(\vec{r}_1)K^*(\vec{r}_2)g\left(\frac{\vec{r}_{\perp 1}}{R}\right)g^*\left(\frac{\vec{r}_{\perp 2}}{R}\right)d\vec{r}_{\perp 1}d\vec{r}_{\perp 2}= \qquad (7.6)$$

$$=\int_{S_\perp}\int_{S_\perp} e^{-ik\frac{r_{\perp 1}^2-r_{\perp 2}^2}{R}+ik\frac{(\vec{\rho}_m\vec{r}_{\perp 1}-\vec{\rho}_n\vec{r}_{\perp 2})}{R}} u(\vec{r}_{\perp 1}-\vec{r}_{\perp 2})\times$$

$$\times\left(1-\frac{\nabla_q\xi(\vec{r}_1)}{N_{q1}}\right)\left(1-\frac{\nabla_q\xi(\vec{r}_2)}{N_{q2}}\right)e^{2ik\left[\left(r_{q1}-N_{q1}\xi(\vec{r}_1)\right)-\left(r_{q2}-N_{q2}\xi(\vec{r}_2)\right)\right]}\times$$

$$\times\psi\left(2\frac{\rho_{nq}-\rho_{mq}+r_{q1}-r_{q2}}{c}\right)K(\vec{r}_1)K^*(\vec{r}_2)g\left(\frac{\vec{r}_{\perp 1}}{R}\right)g^*\left(\frac{\vec{r}_{\perp 2}}{R}\right)d\vec{r}_{\perp 1}d\vec{r}_{\perp 2}.$$

For physical estimations we approximate correlation function $\psi(\Delta t)$ by gaussian function: $\psi(\Delta t)\approx e^{-\frac{(\Delta t)^2}{2\tau^2}}$. Thus we obtain:

$$\overline{F_{mn}(t)}\approx e^{-\frac{(\rho_{mq}-\rho_{nq})^2}{2l_c^2}}\int_{S_\perp}\int_{S_\perp} e^{-ik\frac{r_{\perp 1}^2-r_{\perp 2}^2}{R}+ik\frac{(\vec{\rho}_m\vec{r}_{\perp 1}-\vec{\rho}_n\vec{r}_{\perp 2})}{R}} u(\vec{r}_{\perp 1}-\vec{r}_{\perp 2})\times$$

$$\times\left(1-\frac{\nabla_q\xi(\vec{r}_1)}{N_{q1}}\right)\left(1-\frac{\nabla_q\xi(\vec{r}_2)}{N_{q2}}\right)e^{\left[2ik-\frac{\rho_{mq}-\rho_{nq}}{l_c^2}\right](r_{q1}-r_{q2})-\frac{(r_{q1}-r_{q2})^2}{2l_c^2}-\left(N_{q1}\xi(\vec{r}_1)+N_{q2}\xi(\vec{r}_2)\right)}\times$$

$$\times K(\vec{r}_1)K^*(\vec{r}_2)g\left(\frac{\vec{r}_{\perp 1}}{R}\right)g^*\left(\frac{\vec{r}_{\perp 2}}{R}\right)d\vec{r}_{\perp 1}d\vec{r}_{\perp 2}. \qquad (7.7)$$

Now we conduct an average on $\xi(\vec{r})$ according to a procedure explained in an Appendix. Let's obtain:

$$\langle\overline{F_{mn}(t)}\rangle \approx A\frac{l_\xi^2\lambda^2}{8\pi\sigma_\xi^2}e^{-\frac{(\rho_{mq}-\rho_{nq})^2}{2l_c^2}}\int_{S_\perp} e^{ik\frac{(\vec{\rho}_m-\vec{\rho}_n)\vec{r}_\perp}{R}}\frac{1}{\sqrt{1+\frac{1}{(2kl_c)^2}\frac{l_\xi^2}{\sigma_\xi^2}\frac{N_\perp^2}{N_q^2}}}\times$$

$$\times e^{-\frac{\left[1+i\frac{\rho_{mq}-\rho_{nq}}{2kl_c^2}\right]^2}{1+\frac{1}{(2kl_c)^2}\frac{l_\xi^2N_\perp^2}{\sigma_\xi^2N_q^2}}\cdot\frac{l_\xi^2N_\perp^2}{2\sigma_\xi^2N_q^2}}\left(1+\frac{\sigma_\xi^2}{l_\xi^2}\frac{N_\perp^2}{N_q^2}\right)\frac{|K(\vec{r})|^2}{N_q}\left|g\left(\frac{\vec{r}_\perp}{R}\right)\right|^2 d\vec{r}_\perp \qquad (7.8)$$

If the target is on a vertical axes, so $\rho_{mq}=0$, we obtain:

$$\langle\overline{F_{mn}(t)}\rangle \approx A\frac{l_\xi^2\lambda^2}{8\pi\sigma_\xi^2}\int_{S_\perp} e^{ik\frac{(\vec{\rho}_m-\vec{\rho}_n)\vec{r}_\perp}{R}}\frac{\frac{2kl_c\sigma_\xi}{l_\xi N_\perp}\left(1+\frac{\sigma_\xi^2}{l_\xi^2}\frac{N_\perp^2}{N_q^2}\right)}{\sqrt{1+(2kl_c)^2\frac{\sigma_\xi^2N_q^2}{l_\xi^2N_\perp^2}}}\times$$

$$\times e^{-\frac{2(kl_c)^2}{1+(2kl_c)^2\frac{\sigma_\xi^2N_q^2}{l_\xi^2N_\perp^2}}}\cdot\frac{|K(\vec{r})|^2}{N_q}\left|g\left(\frac{\vec{r}_\perp}{R}\right)\right|^2 d\vec{r}_\perp. \qquad (7.9)$$

From (7.9) it is visible, that the image will register in this case

$$I_0'(\vec{r}_\perp)=e^{-\frac{2(kl_c)^2}{1+(2kl_c)^2\frac{\sigma_\xi^2N_q^2}{l_\xi^2N_\perp^2}}}\cdot\frac{\frac{2kl_c\sigma_\xi}{l_\xi N_\perp}\left(1+\frac{\sigma_\xi^2}{l_\xi^2}\frac{N_\perp^2}{N_q^2}\right)}{\sqrt{1+(2kl_c)^2\frac{\sigma_\xi^2N_q^2}{l_\xi^2N_\perp^2}}}|K(\vec{r})|^2\left|g\left(\frac{\vec{r}_\perp}{R}\right)\right|^2. \qquad (7.10)$$

This image differs from $I_0(\vec{r}_\perp)$ (5.3). In particular, it depends on length of a coherence of radiation l_c. At major l_c it go to $I_0(\vec{r}_\perp)$. And, l_c should not be especially major:

$$kl_c >> \frac{\sigma_\xi}{l_\xi} \sim 10, \quad l_c >> \lambda.$$

However it is very strong on a form of the obtained image renders inclination of a sight line in a case, when the target is not on a vertical. As it is visible from expression (7.8) the signal from a pair of emitters, the difference of optical paths from which in a direction to the target is comparable to length of a coherence of radiation., fades. Therefore angle of deflection of an optical axes from a vertical should obey to an inequality: $Sin\alpha << \frac{l_c}{L_t}$, where L_t – a maximum size of a lattice of emitters.

8. Image reconstruction and estimation of its quality.

The secondary signal processing in the Fourier – telescopy consists in image reconstruction on signals F_{mn}. Let requirements formulated in the previous section are carried out, and F^*_{mn} are proportional with the Fourier – components of image $I(\vec{r}_\perp)$ of the target:

$$F^*_{mn} \sim \int I(\vec{r}_\perp) e^{-ik\frac{(\vec{\rho}_m - \vec{\rho}_n)\vec{r}_\perp}{R}} d\vec{r} = F\left(\frac{k(\vec{\rho}_m - \vec{\rho}_n)}{R}\right). \qquad (8.1)$$

Let's suggest, that the emitters are disposed in nodes of a rectangular lattice with step d, i.e. in points with position vectors $d\vec{a}_m$, where $\vec{a}_m$, $m = 0,...,N$, are integer vectors. Then the quantities F_{nm} are proportional with the Fourier - components on frequencies multiple to $\frac{2\pi d}{L}$, where

$$L = \frac{\lambda R}{d}. \qquad (8.2)$$

The area of an integration in (8.1) natural restricted to sizes of the target. Formally it is possible to take it of any greater size. If distance between emitters d is small enough, thus a maximum linear size of the target $l_{tg} \le L$, then area of an integration in (8.1) can be restricted to quadrate $L \times L$. Then it is possible on coefficients (8.1) with the help of a Fourier series to restore the image periodically repeating on a plane with period L in two directions without superposition of periodically repeating duplicates.. The accuracy of restoring is defined by number used the Fourier -components. Let set of $(N+1)^2$ quantities $F\left(\frac{k(\vec{\rho}_m - \vec{\rho}_n)}{R}\right)$ contains Fourier-components

$$F\left(\frac{2\pi\vec{p}}{L}\right), \quad \vec{p} \in G, \tag{8.3}$$

where G is some two-dimensional set of integer points. The restored image looks like:

$$\tilde{I}(\vec{r}) = \frac{1}{L^2} \sum_{\vec{p} \in G} F\left(\frac{2\pi\vec{p}}{L}\right) e^{\frac{2\pi i}{L}\vec{p}\vec{r}} \tag{8.4}$$

The degree of proximity of functions $\tilde{I}(\vec{r})$ and $I(\vec{r})$ characterizes a resolution capability of a Fourier-telescope defining Fourier-components (8.3). It is easy to see, that

$$\tilde{I}(\vec{r}) = \iint G(\vec{r} - \vec{r}\,')I(\vec{r}\,')d\vec{r}\,', \tag{8.5}$$

where

$$G(\vec{r}) = \frac{1}{L^2} \sum_{\vec{p} \in G} e^{\frac{2\pi i}{L}\vec{p}\vec{r}}. \tag{8.6}$$

The function $G(\vec{r})$ looks like a peak, concentrated above a site by a size $\sigma = \frac{L^2}{M}$, where M – number of points in a set G, i.e. number the Fourier – components used for image reconstruction. From here follows, that the linear resolution capability of Fourier-telescope δ is equal:

$$\delta \approx \frac{L}{\sqrt{M}}. \tag{8.7}$$

. Let's remark now, that the set of $(N+1)^2$ of quantities $F^*_{mn} \sim F\left(\frac{k(\vec{\rho}_m - \vec{\rho}_n)}{R}\right)$ contains different Fourier-components $F\left(\frac{2\pi\vec{a}}{L}\right)$, and many from them are doubled including multiply. As any process of measuring is accompanied by noise, the output signals of Fourier-telescope $F^*_{mn} \sim F\left(\frac{k(\vec{\rho}_m - \vec{\rho}_n)}{R}\right)$ are measured with errors. From here follows, that the backup of the Fourier coefficients should be used for increasing of accuracy of image reconstruction. Taking into account expression (5.2) we can write:

$$F'^*_{mn} = \frac{8\pi\sigma^2_\xi}{l^2_\xi \lambda^2 A} F^*_{mn} = F\left(\frac{k(\vec{\rho}_m - \vec{\rho}_n)}{R}\right) + \xi_{mn},$$

where measurement errors ξ_{mn} we consider independent and Gaussian. From this the following algorithm for optimum image reconstruction $I(\vec{r}_\perp)$ on output signals F_{nm} can be obtained:

$$\sum_{m,n=0}^{N} \left| F'^*_{mn} - \int I(\vec{r}_\perp) e^{-ik\frac{(\vec{\rho}_m - \vec{\rho}_n)\vec{r}_\perp}{R}} d\vec{r}_\perp \right|^2 = \min.$$

Varying on $I(\vec{r}_\perp)$, we obtain the equation:

$$\int I(\vec{r}_{\perp 1}) \left| \sum_{m=0}^{N} e^{\frac{2\pi i}{L}\vec{a}_m(\vec{r}_\perp - \vec{r}_{\perp 1})} \right|^2 d\vec{r}_{\perp 1} = \sum_{m,n=0}^{N} F'^*_{mn} e^{\frac{2\pi i}{L}(\vec{a}_m - \vec{a}_n)\vec{r}_\perp}, \qquad (8.8)$$

where $\vec{a}_m$ is integer position vector of $m-$th emitter. It is possible to enter characteristic function of $m-$ th emitter $\delta\left[\vec{k} - \vec{a}_m\right]$, representing infinite matrix with unity in a point of standing of $m-$ th emitter and zero in remaining points. Equation (8.8) will be copied as:

$$\int I(\vec{r}_{\perp 1}) \left| \sum_{\vec{k}} \Delta(\vec{k}) e^{\frac{2\pi i}{L}\vec{k}(\vec{r}_\perp - \vec{r}_{\perp 1})} \right|^2 d\vec{r}_{\perp 1} = \sum_{m,n=0}^{N} F'^*_{mn} e^{\frac{2\pi i}{L}(\vec{a}_m - \vec{a}_n)\vec{r}_\perp}, \qquad (8.9)$$

where
$$\Delta(\vec{k})=\sum_{m=0}^{N}\delta\left[\vec{k}-\vec{a}_m\right] \tag{8.10}$$

is a characteristic function of all transmitting matrix of emitters representing an infinite matrix with unites in points of standing of emitters and zero in remaining points. Conversing (8.9) by the Fourier, we receive:

$$\int I(\vec{r}_\perp)e^{-\frac{2\pi i}{L}\vec{p}\vec{r}_\perp}d\vec{r}_\perp=\frac{1}{C(\vec{p})}\sum_{m,n=0}^{N}F'^{*}_{mn}\delta\left[\vec{a}_m-\vec{a}_n-\vec{p}\right], \tag{8.11}$$

where

$$C(\vec{p})=\sum_{\vec{k}}\Delta(\vec{k})\Delta(\vec{k}-\vec{p})=\sum_{m,n=0}^{N}\delta\left[\vec{k}-\vec{a}_m\right]\delta\left[\vec{k}-\vec{p}-\vec{a}_n\right]=\sum_{m,n=0}^{N}\delta\left[\vec{a}_m-\vec{a}_n-\vec{p}\right] \tag{8.12}$$

is a number of pairs of emitters, the vector of distance between which is equal $\vec{p}$. The sense of expression (8.11) is very prime: the total of quantities F'^{*}_{mn}, representing the same Fourier coefficient $F\left(\frac{2\pi\vec{p}}{L}\right)$, is divided on total number of such F'^{*}_{mn}, i.e. for image reconstruction the average Fourier coefficients are used.

From (8.11) the following algorithm of image reconstruction implies:

$$I(\vec{r}_\perp)=\frac{1}{L^2}\sum_{\vec{p}\in G}e^{\frac{2\pi i}{L}\vec{p}\vec{r}_\perp}\frac{1}{C(\vec{p})}\sum_{m,n=0}^{N}F'^{*}_{mn}\delta\left[\vec{a}_m-\vec{a}_n-\vec{p}\right]. \tag{8.13}$$

Let's calculate statistical properties of the restored image. First calculate average value. Using (5.2) it is easy to receive:

$$\left\langle I(\vec{r}_\perp)\right\rangle=\frac{1}{L^2}\sum_{\vec{p}\in G}e^{\frac{2\pi i}{L}\vec{p}\vec{r}_\perp}\frac{1}{C(\vec{p})}\sum_{m,n=0}^{N}\left\langle F'^{*}_{mn}\right\rangle\delta\left[\vec{a}_m-\vec{a}_n-\vec{p}\right]=I_0(\vec{r}_\perp). \tag{8.14}$$

Thus, the recovered image on the average is equal $I_0(\vec{r}_\perp)$ (5.3).

Let's calculate correlation function of the restored image. We have:

$$B(\vec{r}_{\perp 1},\vec{r}_{\perp 2}) = \langle I(\vec{r}_{\perp 1})I(\vec{r}_{\perp 2})\rangle - \langle I(\vec{r}_{\perp 1})\rangle\langle I(\vec{r}_{\perp 2})\rangle = \frac{1}{L^4}\sum_{\vec{p},\vec{q}\in G} e^{\frac{2\pi i}{L}(\vec{p}\vec{r}_{\perp 1}-\vec{q}\vec{r}_{\perp 2})} \times \quad (8.15)$$

$$\times \frac{1}{C(\vec{p})C(\vec{q})}\sum_{m,n,k,l=0}^{N}\left[\langle F'^{*}_{mn}F'_{kl}\rangle - \langle F'^{*}_{mn}\rangle\langle F'_{kl}\rangle\right]\delta[\vec{a}_m - \vec{a}_n - \vec{p}]\delta[\vec{a}_k - \vec{a}_l - \vec{q}] =$$

$$= \frac{1}{L^4}\sum_{\vec{p},\vec{q}\in G} e^{\frac{2\pi i}{L}(\vec{p}\vec{r}_{\perp 1}-\vec{q}\vec{r}_{\perp 2})}\frac{1}{C(\vec{p})C(\vec{q})}\int_{S_\perp}\int_{S_\perp}\frac{1}{A^2}h(\vec{r}'_{1\perp} - \vec{r}'_{\perp 2})I_0(\vec{r}'_{\perp 1})I_0(\vec{r}'_{\perp 2})\times$$

$$\times\left\{\sum_{m,n,k,l=0}^{N} e^{-\frac{2\pi i}{L}\left[(\vec{a}_m-\vec{a}_k)\vec{r}'_{\perp 1}-(\vec{a}_n-\vec{a}_l)\vec{r}'_{\perp 2}\right]}\delta[\vec{a}_m - \vec{a}_n - \vec{p}]\delta[\vec{a}_k - \vec{a}_l - \vec{q}]\right\}d\vec{r}'_{\perp 1}d\vec{r}'_{\perp 2} \approx$$

$$\approx \int_{S_\perp}\int_{S_\perp}\frac{1}{A^2}G(\vec{r}_{\perp 1} - \vec{r}'_{\perp 1})G^*(\vec{r}_{\perp 2} - \vec{r}'_{\perp 2})\left|H(\vec{r}'_{1\perp} - \vec{r}'_{\perp 2})\right|^2 h(\vec{r}'_{1\perp} - \vec{r}'_{\perp 2})I_0(\vec{r}'_{\perp 1})I_0(\vec{r}'_{\perp 2})d\vec{r}'_{\perp 1}d\vec{r}'_{\perp 2}$$

where $\qquad H(\vec{r}) = \sum_{m=0}^{N} e^{-\frac{2\pi i}{L}\vec{a}_m\vec{r}}$.

We shall consider a case, when the aperture A_r is great enough and it is possible to consider $h(\Delta\vec{r}_\perp)$ as $\delta-$ figurative in relation to functions under the integral (8.15). It is easy to note, it is necessary that diameter of the receiving aperture $\sqrt{A}$ considerably exceed a maximum linear size of a matrix of emitters L_t: $\sqrt{A} >> L_t$. In this case:

$$B(\vec{r}_{\perp 1},\vec{r}_{\perp 2}) \approx \frac{\lambda^2 R^2}{A} I_0^2(\vec{r}_{\perp 1}), \quad (8.16)$$

where

$$G(\vec{r}_\perp) = \frac{1}{L^2}\sum_{\vec{p}} e^{\frac{2\pi i}{L}\vec{p}\vec{r}_\perp} . \quad (8.17)$$

From here we discover a relative variance of fluctuation of luminosity of the restored image (contrast):

$$C \approx \frac{B(\vec{r}_\perp,\vec{r}_\perp)}{\langle I(\vec{r}_\perp)\rangle^2} \approx \frac{\lambda^2 R^2 N^2}{AL^2} \approx \frac{L_t^2}{A}. \quad (8.18)$$

At $\frac{L_t^2}{A} << 1 \quad C << 1$, i.e. the image not fluctuates and is equal to average value.

Except for contrast of the important property of the image is the medial size of spots d_s. The medial square of a spot can be evaluated under the formula:

$$d_s \approx \frac{\int B(\vec{r}_{\perp 1}, \vec{r}_{\perp 2}) d\vec{r}_{\perp 2}}{B(\vec{r}_{\perp 1}, \vec{r}_{\perp 1})} \approx \frac{L^2}{N^2} \approx \frac{R^2 \lambda^2}{L_t^2} \approx \frac{A}{L_t^2} \delta, \tag{8.19}$$

where $\delta = \frac{R^2 \lambda^2}{A}$ is element of a resolution.

In paper [7] the uniform measure of quality of the image in a coherent light equals to a relative variance of correlation of the medial image and its random realization was entered:

$$\eta = \frac{\left\langle \left\{ \int \langle I(\vec{r}_\perp) \rangle \left[I(\vec{r}_\perp) - \langle I(\vec{r}_\perp) \rangle \right] d\vec{r}_\perp \right\}^2 \right\rangle}{\left\{ \int \langle I(\vec{r}_\perp) \rangle^2 d\vec{r}_\perp \right\}^2} =$$

$$= \frac{\left\langle \left\{ \int \int \langle I(\vec{r}_{\perp 1}) \rangle \langle I(\vec{r}_\perp) \rangle B(\vec{r}_{\perp 1}, \vec{r}_{\perp 2}) d\vec{r}_{\perp 1} d\vec{r}_{\perp 2} \right\}^2 \right\rangle}{\left\{ \int \langle I(\vec{r}_\perp) \rangle^2 d\vec{r}_\perp \right\}^2}. \tag{8.20}$$

The substitution in this formula of expressions (8.13) for $\langle I(\vec{r}_\perp) \rangle$ and (8.14) for $B(\vec{r}_{\perp 1}, \vec{r}_{\perp 2})$ gives:

$$\eta \approx \frac{\lambda^2 R^2}{A S_{tg}} \approx \frac{1}{M}, \tag{8.21}$$

Where $M = \frac{S_{tg}}{\delta}$ is number of elements of a resolution on the target.

Let's consider the problem on an optimum configuration of emitters. From a disposition of emitters it is required, that at their given number the greatest number the Fourier – components should be obtained. For matching different configurations by this measure we use the formula (8.12), which gives number the Fourier – components with frequency $\vec{p}$:

$$C(\vec{p}) = \sum_{\vec{k}} \Delta(\vec{k})\Delta(\vec{k} - \vec{p}). \qquad (8.20)$$

The formula (8.20) shows, that number the Fourier - components with frequency $\vec{p}$ equal to number of self-intersections of a configuration of emitters at its shifted on a vector $\vec{p}$. In fig. 4 the variants of filling of a frequency plane for configurations figured in fig. 5 are figured. In the Table 2 the amounts of emitters for each of surveyed configurations providing the same number M of the Fourier coefficients are represents.

Table 2.

Configuration	**amount of emitters**
Y-figurative	$\sim 1.3\sqrt{M}$
L-figurative	$\sim 1.4\sqrt{M}$
П-figurative	$\sim 1.5\sqrt{M}$
O - figurative	$\sim 1.8\sqrt{M}$
+ Figurative	$\sim 2\sqrt{M}$

From the table it is visible, that the Y-configuration is most favorable, and the +-configuration is least favorable. For providing of the same quality of image reconstruction it is required in Y-configurations 1.5 as many emitters as in + -configuration.

9. Inference and conclusions.

In paper the following outcomes are obtained.

1. The quality of the image obtained by the Fourier - telescopy method is determined by two factors: by a size of the receiving aperture both size and number of emitters of a

transmitting matrix. For deriving the images with given number of elements of a resolution the size of the receiving aperture A should obey to usual Rayleigh measure:

$$\frac{\lambda^2 R^2}{A} >> S_{tg},$$

I.e. the necessary number of Rayleigh elements of a resolution should be stacked on object. However in a case the Fourier – telescopy the receiving telescope appears as a collector of an energy and there is not showed any special requirements to optical quality of a mirror of a telescope . In particular a large receiving aperture can be implemented with the help of spaced small telescopes. The small telescopes should place in nodes of a grid with a pitch $d_r < \dfrac{\lambda R}{l_{tg}}$ and fill in square A.

2. The transmitting matrix can be implemented as two or several bars of emitters located in nodes of a grid with a pitch $d < \dfrac{\lambda R}{l_{tg}}$. For a possibility of embodying of a phase closure method each following emitter of bar should be disposed in adjacent on x or y a node of a grid. The element of a resolution at image reconstruction equal to $\delta \approx \dfrac{\lambda^2 R^2}{d^2 M}$, where M is number of different Fourier-components. $M \sim N^2$, where $N -$ number of emitters. The configuration of a matrix of emitters should be such to provide maximum number of different Fourier-components. Were explored Y-, L-, Ï-, O- and + figurative configuration. The greatest number of Fourier-coefficients has appeared for Y-figurative configuration $\sim\left(\dfrac{N^2}{1.3}\right)$ and least for +- figurative $\sim\left(\dfrac{N^2}{2}\right)$.

3. At embodying the formulated requirements on sizes of receiving and transmitting of the apertures it is possible to receive the image given by expression (5.3):

$$I_0(\vec{r}_\perp) = e^{-\frac{N_\perp^2}{N_q^2}\frac{l_\xi^2}{2\sigma_\xi^2}}\left(1+\frac{\sigma_\xi^2}{l_\xi^2}\frac{N_\perp^2}{N_q^2}\right)\frac{|K(\vec{r})|^2}{N_q}\left|g\left(\frac{\vec{r}_\perp}{R}\right)\right|^2.$$

Such image receives by a standard optical instrument in a natural light.

4. The temporal stability of illumination practically does not influence on quality of the recovered image. The slow temporal stability is cancelled as a result of the procedure of phase closure, the fast temporal stability, bound with a partial coherence of illumination, averages at signal processing.

In this paper we have not touched problems, bound with moving of the target and presence of Doppler shift of frequency. Besides the work of a Fourier-telescope on the remote space target, as a rule, carries at low levels of signals in conditins of the score of quantum. A research of process the Fourier – telescopy in these requirements represents major interest. These problems nor have found reflectings in this report. It is desirable to prolong work on the Fourier - telescopy in these directions. At last, the theoretical researches are bound to making of mathematical models frequently requiring of experimental inspection. Making an experimental bench on the Fourier - telescopy and holding of laboratory experiments therefore is desirable.

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Apendix.

Calculation of $\langle F_{mn} \rangle$. Agrees (4.1):

$$\langle F_{mn} \rangle = \int\limits_{S_\perp} \int\limits_{S_\perp} e^{-ik\frac{r_{\perp 1}^2 - r_{\perp 2}^2}{R} + ik\frac{(\vec{\rho}_m \vec{r}_{\perp 1} - \vec{\rho}_n \vec{r}_{\perp 2})}{R}} u(\vec{r}_{\perp 1} - \vec{r}_{\perp 2}) \times$$

$$\times \left\langle \left(1 - \frac{\nabla_q \xi(\vec{r}_1)}{N_{q1}}\right)\left(1 - \frac{\nabla_q \xi(\vec{r}_2)}{N_{q2}}\right) \right\rangle \left\langle e^{2ik\left[\left(r_{q1} - N_{q1}\xi(\vec{r}_1)\right) - \left(r_{q2} - N_{q2}\xi(\vec{r}_2)\right)\right]} \right\rangle \times$$

$$\times K(\vec{r}_1) K^*(\vec{r}_2) g\left(\frac{\vec{r}_{\perp 1}}{R}\right) g^*\left(\frac{\vec{r}_{\perp 2}}{R}\right) d\vec{r}_{\perp 1} d\vec{r}_{\perp 2}. \qquad \text{(A.1)}$$

Since $\xi(\vec{r})$ is Gaussian we have:

$$\left\langle e^{-2ik\left(N_{1q}\xi(\vec{r}_1) - N_{2q}\xi(\vec{r}_2)\right)} \right\rangle = e^{-2k^2\sigma_\xi^2\left(N_{1q}^2 + N_{2q}^2 - 2N_{1q}N_{2q}b(\vec{r}_1, \vec{r}_2)\right)} \approx$$

$$\approx e^{-4k^2\sigma_\xi^2 N_{1q}^2 \left(1 - b(\vec{r}_1, \vec{r}_2)\right)}. \qquad \text{(A.2)}$$

Here is designated: $\sigma_\xi^2 = B(\vec{r}, \vec{r}), \quad b(\vec{r}_1, \vec{r}_2) = \dfrac{B(\vec{r}_1, \vec{r}_2)}{B(\vec{r}, \vec{r})}$. We have taken advantage of that radius of correlation of micro unevennesses $\xi(\vec{r})$ is rather small in comparison with reference scales of a relief of a underlying surface. Let's suggest that $\sigma_\xi >> \lambda$. In this assumption the function (A.2) is rather acute the peak concentrated in limits of locally flat site of a underlying surface. In limits of this site it is possible to enter orthogonal coordinate system u,v. We use for analytical estimations Gaussian approximation of correlation function:

$$b(\vec{r}(u_1,v_1),\vec{r}(u_2,v_2)) \approx e^{-\frac{(u_1-v_1)^2+(u_2-v_2)^2}{2l_\xi^2}}. \qquad \text{(A.3)}$$

Thus the function (A.2) can be approximated as follows:

$$\left\langle e^{-2ik\left[N_{1q}\xi(\vec{r}(u_1,v_1))-N_{2q}\xi(\vec{r}(u_2,v_2))\right]}\right\rangle \approx e^{-4k^2\sigma_\xi^2 N_{1q}^2\left(1-e^{-\frac{(u_1-v_1)^2+(u_2-v_2)^2}{2l_\xi^2}}\right)} \approx$$

$$\approx e^{-4k^2\sigma_\xi^2 N_{1q}^2 \frac{(u_1-v_1)^2+(u_2-v_2)^2}{2l_\xi^2}}. \qquad \text{(A.4)}$$

Supposing $\vec{r}=\vec{r}_0+\vec{\mu}\cdot u+\vec{\nu}\cdot v$, we can obtain:

$$\left\langle\left(N_{1q}-\nabla_q\xi(\vec{r}_1)\right)\left(N_{2q}-\nabla_q\xi(\vec{r}_2)\right)\right\rangle = N_{1q}N_{2q}+$$

$$+\left\langle\left(\mu_q\frac{\partial\xi(\vec{r}_1)}{\partial u_1}+\nu_q\frac{\partial\xi(\vec{r}_1)}{\partial v_1}\right)\left(\mu_q\frac{\partial\xi(\vec{r}_2)}{\partial u_2}+\nu_q\frac{\partial\xi(\vec{r}_2)}{\partial v_2}\right)\right\rangle = N_{1q}N_{2q}+$$

$$+\mu_q^2\frac{\partial^2 B(\vec{r}_1,\vec{r}_2)}{\partial u_1\partial u_2}+\mu_q\nu_q\frac{\partial^2 B(\vec{r}_1,\vec{r}_2)}{\partial u_1\partial v_2}+\mu_q\nu_q\frac{\partial^2 B(\vec{r}_1,\vec{r}_2)}{\partial v_1\partial u_2}+\nu_q^2\frac{\partial^2 B(\vec{r}_1,\vec{r}_2)}{\partial v_1\partial v_2}=$$

$$=N_{1q}N_{2q}+B(\vec{r}_1,\vec{r}_2)\left[\mu_q^2\left(-\frac{(u_1-u_2)^2}{l_\xi^4}+\frac{1}{l_\xi^2}\right)-2\mu_q\nu_q\frac{(u_1-u_2)(v_1-v_2)}{l_\xi^4}+\nu_q^2\left(-\frac{(v_1-v_2)^2}{l_\xi^4}+\right.\right.$$

$$=N_{1q}N_{2q}+B(\vec{r}_1,\vec{r}_2)\left(-\frac{\left(\mu_q(u_1-u_2)+\nu_q(v_1-v_2)\right)^2}{l_\xi^4}+\frac{\mu_q^2+\nu_q^2}{l_\xi^2}\right)=$$

$$=N_{1q}N_{2q}+B(\vec{r}_1,\vec{r}_2)\left(-\frac{\left(\mu_q(u_1-u_2)+\nu_q(v_1-v_2)\right)^2}{l_\xi^4}+\frac{N_\perp^2}{l_\xi^2}\right). \qquad \text{(A.5)}$$

Let's mark, that the function (A.4) is $\delta-$figurative in relation to function (A.4). Character length of a peak of function (A.5), agrees (A.3), makes l_ξ. Character length of a peak of function (A.4) makes $\frac{l_\xi}{2k\sigma_\xi N_{1q}}$, that at $\frac{\sigma_\xi}{\lambda} >> 1$ is much less. We suggest also, that mikro unevenness are not resolved by the aperture A, i.e. the function (A.3) is $\delta-$ figurative in relation to function $u(\vec{r}_\perp)$.

Using made estimations, we obtain:

$$\int_S \left\langle e^{2ik\left[\left(r_{q1}-N_{q1}\xi(\vec{r}_1)\right)-\left(r_{q2}-N_{q2}\xi(\vec{r}_2)\right)\right]}\right\rangle \left\langle \left(N_{q1}-\nabla_q\xi(\vec{r}_1)\right)\left(N_{q2}-\nabla_q\xi(\vec{\rho}_2)\right)\right\rangle dS_2 \approx$$

$$\approx \int_S e^{2ik\left(\mu_q(u_1-u_2)+\nu_q(v_1-v_2)\right)-4k^2\sigma_\xi^2 N_{1q}^2 \frac{(u_1-u_2)^2+(v_1-v_2)^2}{2l_\xi^2}} \times$$

$$\times \left\{ N_{1q}N_{2q} + B(\vec{r}_1,\vec{r}_2)\left(-\frac{\left(\mu_q(u_1-u_2)+\nu_q(v_1-v_2)\right)^2}{l_\xi^4}+\frac{N_\perp^2}{l_\xi^2}\right)\right\} du_2 dv_2 \approx$$

$$\approx \frac{l_\xi^2\lambda^2}{8\pi\sigma_\xi^2 N_q^2} e^{-\frac{N_\perp^2}{N_q^2}\frac{l_\xi^2}{2\sigma_\xi^2}}\left(1+\frac{\sigma_\xi^2}{l_\xi^2}\frac{N_\perp^2}{N_q^2}\right). \tag{A.6}$$

Substituting (A.6) in (A.1) we obtain:

$$\left\langle F_{mn}\right\rangle = \frac{l_\xi^2\lambda^2}{8\pi\sigma_\xi^2} I_0(\vec{r}_\perp). \tag{A.7}$$

Calculation $\left\langle F_{mn}F_{kl}^*\right\rangle$. We have:

$$\left\langle F_{mn}F_{kl}^*\right\rangle = \int_S\int_S\int_S\int_S e^{-ik\frac{r_{\perp1}^2-r_{\perp2}^2-r_{\perp3}^2+r_{\perp4}^2}{R}+ik\frac{\vec{\rho}_m\vec{r}_{\perp1}-\vec{\rho}_n\vec{r}_{\perp2}-\vec{\rho}_k\vec{r}_{\perp3}+\vec{\rho}_l\vec{r}_{\perp4})}{R}} u(\vec{r}_{\perp1}-\vec{r}_{\perp2})u^*(\vec{r}_{\perp3}-\vec{r}_{\perp4})$$

$$\times e^{2ik\left(r_{q1}-r_{q2}-r_{q3}+r_{q4}\right)}\left\langle e^{-2ik\left(N_{q1}\xi(\vec{r}_1)-N_{q2}\xi(\vec{r}_2)-N_{q3}\xi(\vec{r}_3)+N_{q4}\xi(\vec{r}_4)\right)}\right\rangle \times \tag{A.8}$$

$$\times \left\langle \left(N_{q1}-\nabla_q\xi(\vec{r}_{q1})\right)\left(N_{q2}-\nabla_q\xi(\vec{r}_2)\right)\left(N_{q3}-\nabla_q\xi(\vec{r}_{q3})\right)\left(N_{q4}-\nabla_q\xi(\vec{r}_4)\right)\right\rangle \times$$

$$\times K(\vec{r}_1)K^*(\vec{r}_2)K^*(\vec{r}_3)K(\vec{r}_4)g\left(\frac{\vec{r}_{\perp 1}}{R}\right)g^*\left(\frac{\vec{r}_{\perp 2}}{R}\right)g^*\left(\frac{\vec{r}_{\perp 3}}{R}\right)g\left(\frac{\vec{r}_{\perp 4}}{R}\right)dS_1dS_2dS_3dS_4$$

Having taken advantage that $\xi(\vec{r})$ is Gaussian, we obtain:

$$\left\langle e^{-2ik\left(N_{1q}\xi(\vec{r}_1)-N_{2q}\xi(\vec{r}_2)-N_{3q}\xi(\vec{r}_3)+N_{4q}\xi(\vec{r}_4)\right)}\right\rangle =$$

$$= e^{-2k^2\sigma_\xi^2\left(N_{1q}^2+N_{2q}^2+N_{3q}^2+N_{4q}^2\right)}\times$$
$$= e^{-4k^2\left(-N_{1q}N_{2q}b(\vec{r}_1,\vec{r}_2)-N_{1q}N_{3q}b(\vec{r}_1,\vec{r}_3)+N_{1q}N_{4q}b(\vec{r}_1,\vec{r}_4)\right)}\times$$
$$= e^{-4k^2\left(N_{2q}N_{3q}b(\vec{r}_2,\vec{r}_3)-N_{2q}N_{4q}b(\vec{r}_2,\vec{r}_4)-N_{3q}N_{4q}b(\vec{r}_3,\vec{r}_4)\right)} \qquad \text{(A.9)}$$

This function has two peaks with single maxims on diversities $\vec{r}_1=\vec{r}_2,\ \ \vec{r}_3=\vec{r}_4$ and $\vec{r}_1=\vec{r}_3,\ \ \vec{r}_2=\vec{r}_4$. These peaks are rather acute, practically δ – figurative. Therefore function (A.8) can be represented as the total of these peaks. For analytical estimations it can be used Gaussian approximation of peaks similar (A.3)

For approximating of a peak in an environ of a diversity $\vec{r}_1=\vec{r}_2,\ \ \vec{r}_3=\vec{r}_4$, let's assume $\vec{r}_2=\vec{r}_1+\vec{x},\ \ \vec{r}_4=\vec{r}_3+\vec{y}$. Let's suggest, that the peak concentrated in the field of small $\vec{x}$ and $\vec{y}$ in limits locally of flat sites of a underlying surface in an environ of points $\vec{r}_1,\vec{r}_3$. Let's receive:

$$f(\vec{r}_1,\vec{r}_1+\vec{x},\vec{r}_3,\vec{r}_3+\vec{y})=$$
$$= e^{-4k^2\sigma_\xi^2\left[N_{1q}^2\left(1-b(\vec{r}_1,\vec{r}_1+\vec{x})\right)+N_{3q}^2\left(1-b(\vec{r}_3,\vec{r}_3+\vec{y})\right)\right]}\times$$
$$= e^{-4k^2\sigma_\xi^2N_{1q}N_{3q}\left[-b(\vec{r}_1,\vec{r}_3)+b(\vec{r}_1,\vec{r}_3+\vec{y})+b(\vec{r}_1+\vec{x},\vec{r}_3)-b(\vec{r}_1+\vec{x},\vec{r}_3+\vec{y})\right]}\approx$$
$$\approx e^{-4k^2\sigma_\xi^2\left(N_{1q}^2\frac{x^2}{2l_\xi^2}+N_{3q}^2\frac{y^2}{2l_\xi^2}\right)}\times$$

$$\times e^{-4k^2\sigma_\xi^2 N_{1q}N_{3q}\left(-b(\vec{r}_1,\vec{r}_3)+b(\vec{r}_1,\vec{r}_3+\vec{y})+b(\vec{r}_1+\vec{x},\vec{r}_3)-b(\vec{r}_1+\vec{x},\vec{r}_3+\vec{y})\right)} \approx$$

$$\approx e^{-4k^2\sigma_\xi^2\left(N_{1q}^2\frac{|\vec{r}_1-\vec{r}_2|^2}{2l_\xi^2}+N_{3q}^2\frac{|\vec{r}_3-\vec{r}_4|^2}{2l_\xi^2}\right)}. \qquad \text{(A.10)}$$

For approximating of a peak in an environ of a diversity $\vec{r}_1=\vec{r}_3$, $\vec{r}_2=\vec{r}_4$, let's assume $\vec{r}_3=\vec{r}_1+\vec{x}$, $\vec{r}_4=\vec{r}_2+\vec{y}$. The peak concentrated in the field of small $\vec{x}$ and $\vec{y}$ in limits of locally flat sites of a underlying surface in an environ of points $\vec{r}_1,\vec{r}_2$. Let's obtain:

$$f(\vec{r}_1,\vec{r}_2,\vec{r}_1+\vec{x},\vec{r}_2+\vec{y})=$$

$$=e^{-4k^2\sigma_\xi^2\left[N_{1q}^2\left(1-b(\vec{r}_1,\vec{r}_1+\vec{x})\right)+N_{2q}^2\left(1-b(\vec{r}_2,\vec{r}_2+\vec{y})\right)\right]}\times$$

$$\times e^{-4k^2\sigma_\xi^2 N_{1q}N_{2q}\left(-b(\vec{r}_1,\vec{r}_2)+b(\vec{r}_1,\vec{r}_2+\vec{y})+b(\vec{r}_2,\vec{r}_1+\vec{x})-b(\vec{r}_1+\vec{x},\vec{r}_2+\vec{y})\right)} \approx$$

$$\approx e^{-4k^2\sigma_\xi^2\left(N_{1q}^2\frac{x^2}{2l_\xi^2}+N_{2q}^2\frac{y^2}{2l_\xi^2}\right)}\times$$

$$\times e^{-4k^2\sigma_\xi^2 N_{1q}N_{2q}\left(-b(\vec{r}_1,\vec{r}_2)+b(\vec{r}_1,\vec{r}_2+\vec{y})-b(\vec{r}_2,\vec{r}_1+\vec{x})-b(\vec{r}_1+\vec{x},\vec{r}_2+\vec{y})\right)} \approx$$

$$\approx e^{-4k^2\sigma_\xi^2\left(N_{1q}^2\frac{|\vec{r}_1-\vec{r}_3|^2}{2l_\xi^2}+N_{2q}^2\frac{|\vec{r}_2-\vec{r}_4|^2}{2l_\xi^2}\right)}. \qquad \text{(A.11)}$$

From here:

$$\left\langle e^{-2ik\left(N_{1q}\xi(\vec{r}_1)-N_{2q}\xi(\vec{r}_2)+N_{3q}\xi(\vec{r}_3)-N_{4q}\xi(\vec{r}_4)\right)}\right\rangle \approx \qquad \text{(A.12)}$$

$$\approx e^{-4k^2\sigma_\xi^2\left(N_{1q}^2\frac{|\vec{r}_1-\vec{r}_2|^2}{2l_\xi^2}+N_{3q}^2\frac{|\vec{r}_3-\vec{r}_4|^2}{2l_\xi^2}\right)}+e^{-4k^2\sigma_\xi^2\left(N_{1q}^2\frac{|\vec{r}_1-\vec{r}_3|^2}{2l_\xi^2}+N_{2q}^2\frac{|\vec{r}_2-\vec{r}_4|^2}{2l_\xi^2}\right)}.$$

The substitution (A.12) in (A.8) gives:

$$\left\langle F_{mn}F_{kl}^{*}\right\rangle = \left\langle F_{mn}\right\rangle\left\langle F_{kl}^{*}\right\rangle + \iint\limits_{S\,S}\iint\limits_{S\,S} e^{-ik\frac{r_{\perp 1}^{2}-r_{\perp 2}^{2}-r_{\perp 3}^{2}+r_{\perp 4}^{2}}{R}+ik\frac{\vec{\rho}_m\vec{r}_{\perp 1}-\vec{\rho}_n\vec{r}_{\perp 2}-\vec{\rho}_k\vec{r}_{\perp 3}+\vec{\rho}_l\vec{r}_{\perp 4})}{R}} u(\vec{r}_{\perp 1}-\vec{r}_{\perp 2}$$

$$\times e^{2ik\left(r_{q1}-r_{q2}-r_{q3}+r_{q4}\right)-4k^{2}\sigma_{\xi}^{2}\left(N_{1q}^{2}\frac{\left|\vec{r}_1-\vec{r}_3\right|^{2}}{2l_{\xi}^{2}}+N_{2q}^{2}\frac{\left|\vec{r}_2-\vec{r}_4\right|^{2}}{2l_{\xi}^{2}}\right)}\times$$

$$\times\left\langle\left(N_{q1}-\nabla_q\xi(\vec{r}_{q1})\right)\left(N_{q2}-\nabla_q\xi(\vec{r}_2)\right)\left(N_{q3}-\nabla_q\xi(\vec{r}_{q3})\right)\left(N_{q4}-\nabla_q\xi(\vec{r}_4)\right)\right\rangle\times$$

$$\times K(\vec{r}_1)K^{*}(\vec{r}_2)K^{*}(\vec{r}_3)K(\vec{r}_4)g\left(\frac{\vec{r}_{\perp 1}}{R}\right)g^{*}\left(\frac{\vec{r}_{\perp 2}}{R}\right)g^{*}\left(\frac{\vec{r}_{\perp 3}}{R}\right)g\left(\frac{\vec{r}_{\perp 4}}{R}\right)dS_1dS_2dS_3dS_4,$$

$$\left\langle F_{mn}F_{kl}^{*}\right\rangle - \left\langle F_{mn}\right\rangle\left\langle F_{kl}^{*}\right\rangle = \iint\limits_{S\,S}\iint\limits_{S\,S} h(\vec{r}_{1\perp}-\vec{r}_{\perp 2})e^{2ik\left(r_{q1}-r_{q2}-r_{q3}+r_{q4}\right)-4k^{2}\sigma_{\xi}^{2}\left(N_{1q}^{2}\frac{\left|\vec{r}_1-\vec{r}_3\right|^{2}}{2l_{\xi}^{2}}+N_{2q}^{2}\frac{\left|\vec{r}_2-\vec{r}_4\right|^{2}}{2l_{\xi}^{2}}\right.}$$

$$\times e^{ik\frac{(\vec{\rho}_m-\vec{\rho}_k)\vec{r}_{\perp 1}-(\vec{\rho}_n-\vec{\rho}_l)\vec{r}_{\perp 2}}{R}}\left\langle\left(N_{q1}-\nabla_q\xi(\vec{r}_1)\right)^{2}\left(N_{q2}-\nabla_q\xi(\vec{r}_2)\right)^{2}\right\rangle\times$$

$$\times\left|K(\vec{r}_1)\right|^{2}\left|K(\vec{r}_2)\right|^{2}\left|g\left(\frac{\vec{r}_{\perp 1}}{R}\right)\right|^{2}\left|g\left(\frac{\vec{r}_{\perp 2}}{R}\right)\right|^{2}dS_1dS_2dS_3dS_4\approx$$

$$\approx\iint\limits_{S\,S}h(\vec{r}_{1\perp}-\vec{r}_{\perp 2})e^{ik\frac{(\vec{\rho}_m-\vec{\rho}_k)\vec{r}_{\perp 1}-(\vec{\rho}_n-\vec{\rho}_l)\vec{r}_{\perp 2}}{R}}\frac{l_{\xi}^{2}\lambda^{2}}{8\pi\sigma_{\xi}^{2}N_{1q}^{2}}e^{-\frac{N_{1\perp}^{2}}{N_{1q}^{2}}\frac{l_{\xi}^{2}}{2\sigma_{\xi}^{2}}}\frac{l_{\xi}^{2}\lambda^{2}}{8\pi\sigma_{\xi}^{2}N_{2q}^{2}}e^{-\frac{N_{2\perp}^{2}}{N_{2q}^{2}}\frac{l_{\xi}^{2}}{2\sigma_{\xi}^{2}}}\times$$

$$\times\left\{\left(N_{1q}^{2}+\left\langle\left(\nabla_q\xi(\vec{r}_1)\right)^{2}\right\rangle\right)\left(N_{2q}^{2}+\left\langle\left(\nabla_q\xi(\vec{r}_1)\right)^{2}\right\rangle\right)+4N_{1q}^{2}\left\langle\left(\nabla_q\xi(\vec{r}_1)\right)\left(\nabla_q\xi(\vec{r}_2)\right)\right\rangle+\right.$$

$$\left.+2\left\langle\left(\nabla_q\xi(\vec{r}_1)\right)\left(\nabla_q\xi(\vec{r}_2)\right)\right\rangle^{2}\right\}\left|K(\vec{r}_1)\right|^{2}\left|K(\vec{r}_2)\right|^{2}\left|g\left(\frac{\vec{r}_{\perp 1}}{R}\right)\right|^{2}\left|g\left(\frac{\vec{r}_{\perp 2}}{R}\right)\right|^{2}dS_1dS_2\approx$$

$$\approx\left(\frac{l_{\xi}^{2}\lambda^{2}}{8\pi\sigma_{\xi}^{2}}\right)^{2}\iint\limits_{S\,S}h(\vec{r}_{1\perp}-\vec{r}_{\perp 2})e^{ik\frac{(\vec{\rho}_m-\vec{\rho}_k)\vec{r}_{\perp 1}-(\vec{\rho}_n-\vec{\rho}_l)\vec{r}_{\perp 2}}{R}}e^{-\frac{N_{1\perp}^{2}}{N_{1q}^{2}}\frac{l_{\xi}^{2}}{2\sigma_{\xi}^{2}}-\frac{N_{2\perp}^{2}}{N_{2q}^{2}}\frac{l_{\xi}^{2}}{2\sigma_{\xi}^{2}}}\left\{\left(1+\frac{\sigma_{\xi}^{2}}{l_{\xi}^{2}}\frac{N_{1\perp}^{2}}{N_{1q}^{2}}\right)\left(1+\frac{}{l}\right.\right.$$

$$\left.+\left[4N_{1q}^{2}B(\vec{r}_1,\vec{r}_2)+2B(\vec{r}_1,\vec{r}_2)^{2}\left[\frac{N_{1\perp}^{2}}{l_{\xi}^{2}}-\frac{\left(\mu_q(u_1-u_2)+\nu_q(v_1-v_2)\right)^{2}}{l_{\xi}^{4}}\right]\right]\right\}\times$$

$$\times\left|K(\vec{r}_1)\right|^2\left|K(\vec{r}_2)\right|^2\left|g\left(\frac{\vec{r}_{\perp 1}}{R}\right)\right|^2\left|g\left(\frac{\vec{r}_{\perp 2}}{R}\right)\right|^2 dS_1 dS_2$$

We here have taken advantage of the formula:

$$\left\langle \nabla_q \xi(\vec{r}_1)\nabla_q \xi(\vec{r}_2)\right\rangle \approx B(\vec{r}_1,\vec{r}_2)\left(\frac{N_{1\perp}^2}{l_\xi^2}-\frac{\left(\mu_q(u_1-u_2)+\nu_q(v_1-v_2)\right)^2}{l_\xi^4}\right).$$

From here: $\left\langle\left(\nabla_q \xi(\vec{r})\right)^2\right\rangle=\frac{\sigma_\xi^2}{l_\xi^2}N_\perp^2$.

Finally we obtain:

$$\left\langle F_{mn}F_{kl}^*\right\rangle-\left\langle F_{mn}\right\rangle\left\langle F_{kl}^*\right\rangle \approx$$

$$\approx\left(\frac{l_\xi^2\lambda^2}{8\pi\sigma_\xi^2}\right)^2\int\limits_S\int\limits_S h(\vec{r}_{1\perp}-\vec{r}_{\perp 2})e^{ik\frac{(\vec{\rho}_m-\vec{\rho}_k)\vec{r}_{\perp 1}-(\vec{\rho}_n-\vec{\rho}_l)\vec{r}_{\perp 2}}{R}}e^{-\left(\frac{N_{1\perp}^2}{N_{1q}^2}+\frac{N_{2\perp}^2}{N_{2q}^2}\right)\frac{l_\xi^2}{2\sigma_\xi^2}}\left(1+\frac{\sigma_\xi^2}{l_\xi^2}\frac{N_{1\perp}^2}{N_{1q}^2}\right)\left(1+\frac{\sigma_\xi^2}{l_\xi^2}\cdots\right.$$

$$\times\left|K(\vec{r}_1)\right|^2\left|K(\vec{r}_2)\right|^2\left|g\left(\frac{\vec{r}_{\perp 1}}{R}\right)\right|^2\left|g\left(\frac{\vec{r}_{\perp 2}}{R}\right)\right|^2 dS_1 dS_2 + \qquad \text{(A.13)}$$

$$+\frac{3\lambda^4 l_\xi^2 A^2}{128\pi}\int\limits_S e^{ik\frac{(\vec{\rho}_m-\vec{\rho}_k-\vec{\rho}_n+\vec{\rho}_l)\vec{r}_{\perp 1}}{R}}e^{-\frac{N_\perp^2}{N_q^2}\frac{l_\xi^2}{\sigma_\xi^2}}\left|K(\vec{r})\right|^4\left|g\left(\frac{\vec{r}_\perp}{R}\right)\right|^4\frac{N_\perp^4}{N_q}dS.$$

Using the formula (5.3), we can write:

$$\left\langle F_{mn}F_{kl}^*\right\rangle-\left\langle F_{mn}\right\rangle\left\langle F_{kl}^*\right\rangle \approx$$

$$\approx\left(\frac{l_\xi^2\lambda^2}{8\pi\sigma_\xi^2}\right)^2\int\limits_{S_\perp}\int\limits_{S_\perp} h(\vec{r}_{1\perp}-\vec{r}_{\perp 2})e^{ik\frac{(\vec{\rho}_m-\vec{\rho}_k)\vec{r}_{\perp 1}-(\vec{\rho}_n-\vec{\rho}_l)\vec{r}_{\perp 2}}{R}} I_0(\vec{r}_{\perp 1})I_0(\vec{r}_{\perp 2})d\vec{r}_{\perp 1}d\vec{r}_{\perp 2}$$

$$+\frac{3\lambda^4 l_\xi^2 A^2}{128\pi}\int\limits_{S_\perp} e^{ik\frac{(\vec{\rho}_m-\vec{\rho}_k-\vec{\rho}_n+\vec{\rho}_l)\vec{r}_{\perp 1}}{R}}\frac{I_0^2(\vec{r}_\perp)N_\perp^4}{\left(1+\frac{\sigma_\xi^2}{l_\xi^2}\frac{N_\perp^2}{N_q^2}\right)^2}d\vec{r}_\perp. \qquad \text{(A.14)}$$

Following outcome here is used:

$$\int\limits_S \left[4N_{1q}^2 B(\vec{r}_1,\vec{r}_2) + 2B(\vec{r}_1,\vec{r}_2)^2\right] \left(\frac{N_{1\perp}^2}{l_\xi^2} - \frac{\left(\mu_q(u_1-u_2)+\nu_q(v_1-v_2)\right)^2}{l_\xi^4} \right) dS_2 \approx \frac{3\pi\sigma_\xi^4 N_{1\perp}^4}{2l_\xi^2 N_q}$$

It is easy to note, that second term in (A.14) neglectfully small in comparison with the first term. Their ration varies from $\frac{\sigma_\xi^4}{S_\perp l_\xi^2}$ at the small apertures A up to $\frac{\sigma_\xi^4 A}{R^2\lambda^2 l_\xi^2}$ at the large apertures. Therefore finally we have:

$$\left\langle F_{mn}F_{kl}^*\right\rangle - \left\langle F_{mn}\right\rangle\left\langle F_{kl}^*\right\rangle \approx \qquad \text{(A.15)}$$

$$\approx \left(\frac{l_\xi^2\lambda^2}{8\pi\sigma_\xi^2}\right)^2 \int\limits_{S_\perp}\int\limits_{S_\perp} h(\vec{r}_{1\perp}-\vec{r}_{\perp 2}) e^{ik\frac{(\vec{\rho}_m-\vec{\rho}_k)\vec{r}_{\perp 1}-(\vec{\rho}_n-\vec{\rho}_l)\vec{r}_{\perp 2}}{R}} I_0(\vec{r}_{\perp 1}) I_0(\vec{r}_{\perp 2}) d\vec{r}_{\perp 1} d\vec{r}_{\perp 2}.$$

In particular we obtain:

$$\left\langle \left|F_{mn}\right|^2\right\rangle - \left|\left\langle F_{mn}\right\rangle\right|^2 \approx\approx \left(\frac{l_\xi^2\lambda^2}{8\pi\sigma_\xi^2}\right)^2 \int\limits_{S_\perp}\int\limits_{S_\perp} h(\vec{r}_{1\perp}-\vec{r}_{\perp 2}) I_0(\vec{r}_{\perp 1}) I_0(\vec{r}_{\perp 2}) d\vec{r}_{\perp 1} d\vec{r}_{\perp 2}$$

(A16)

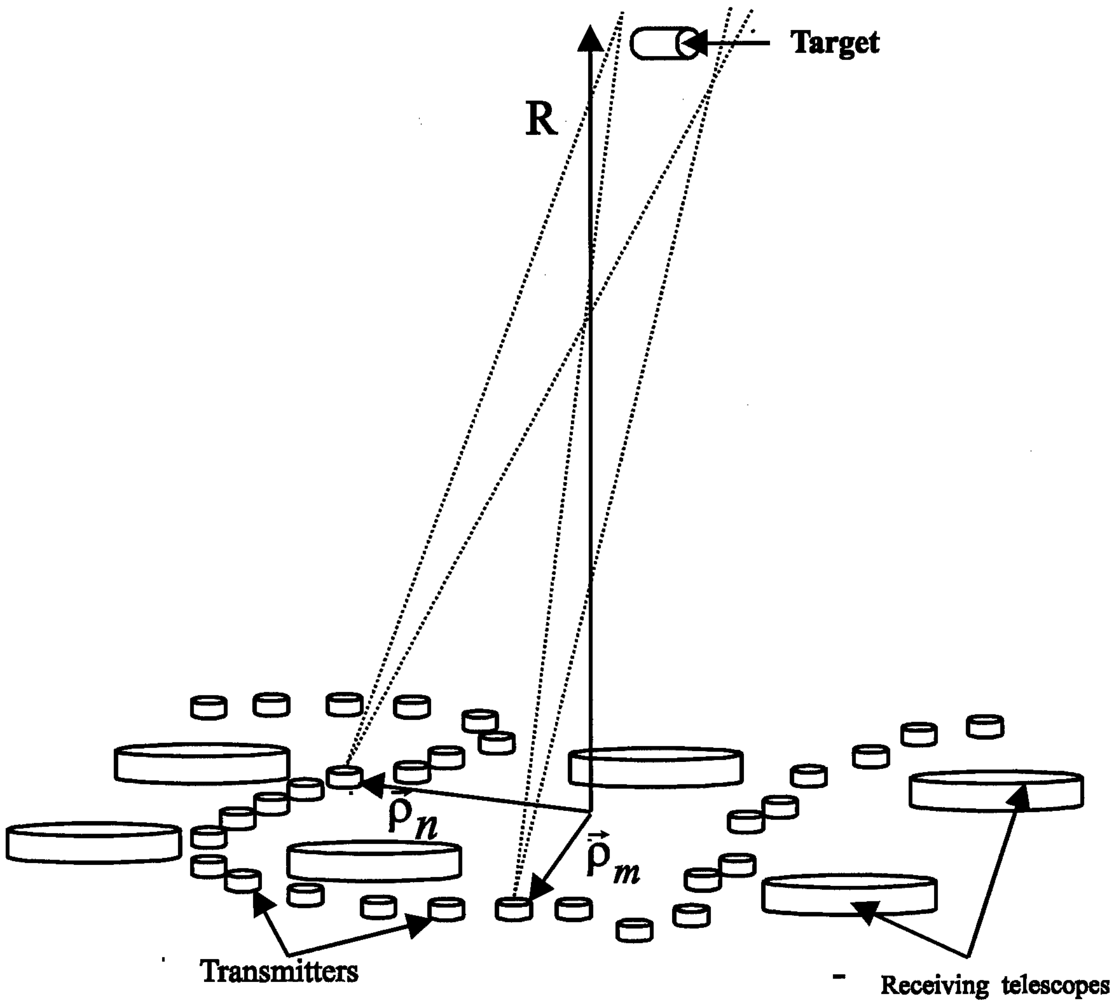
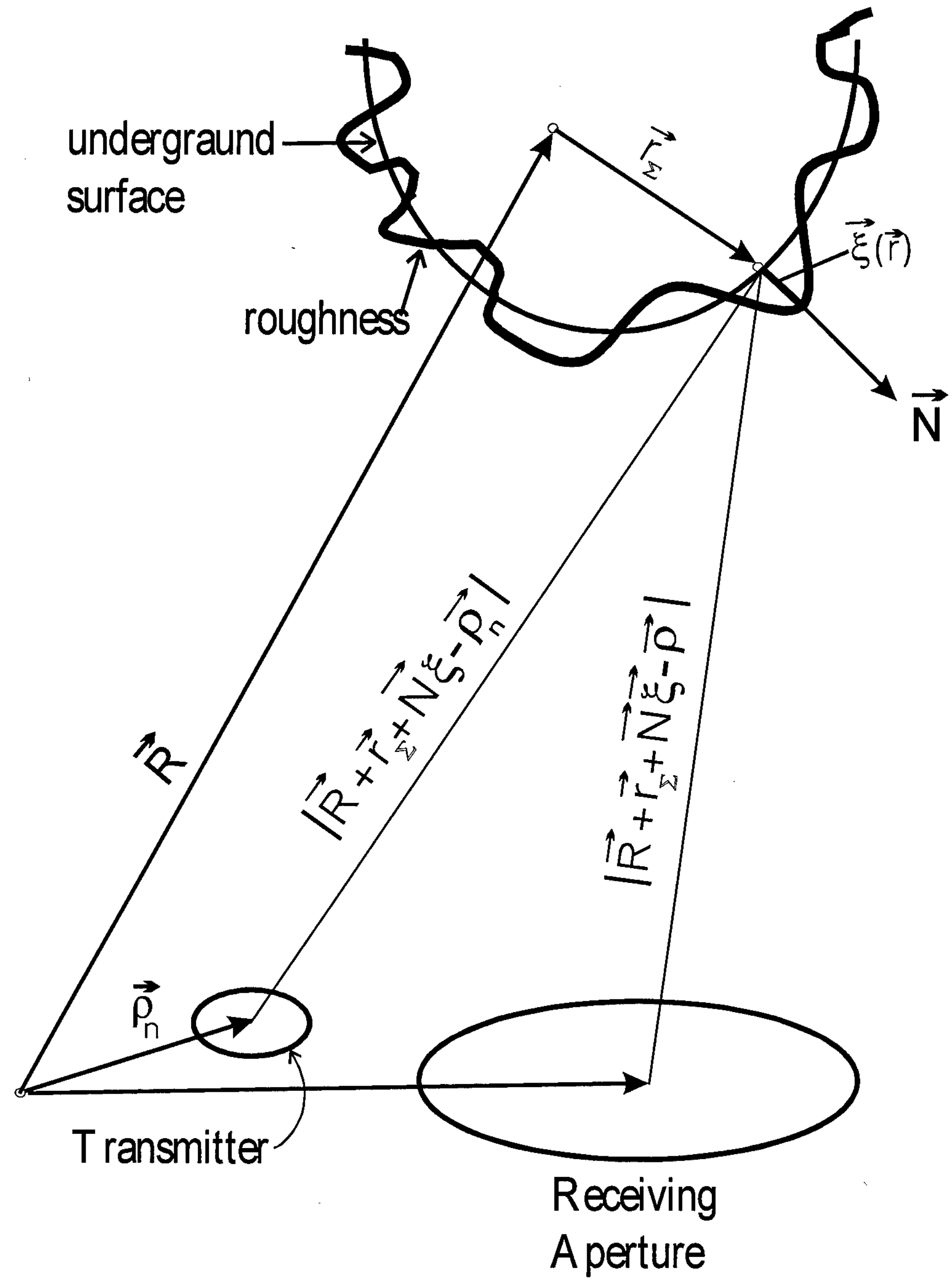
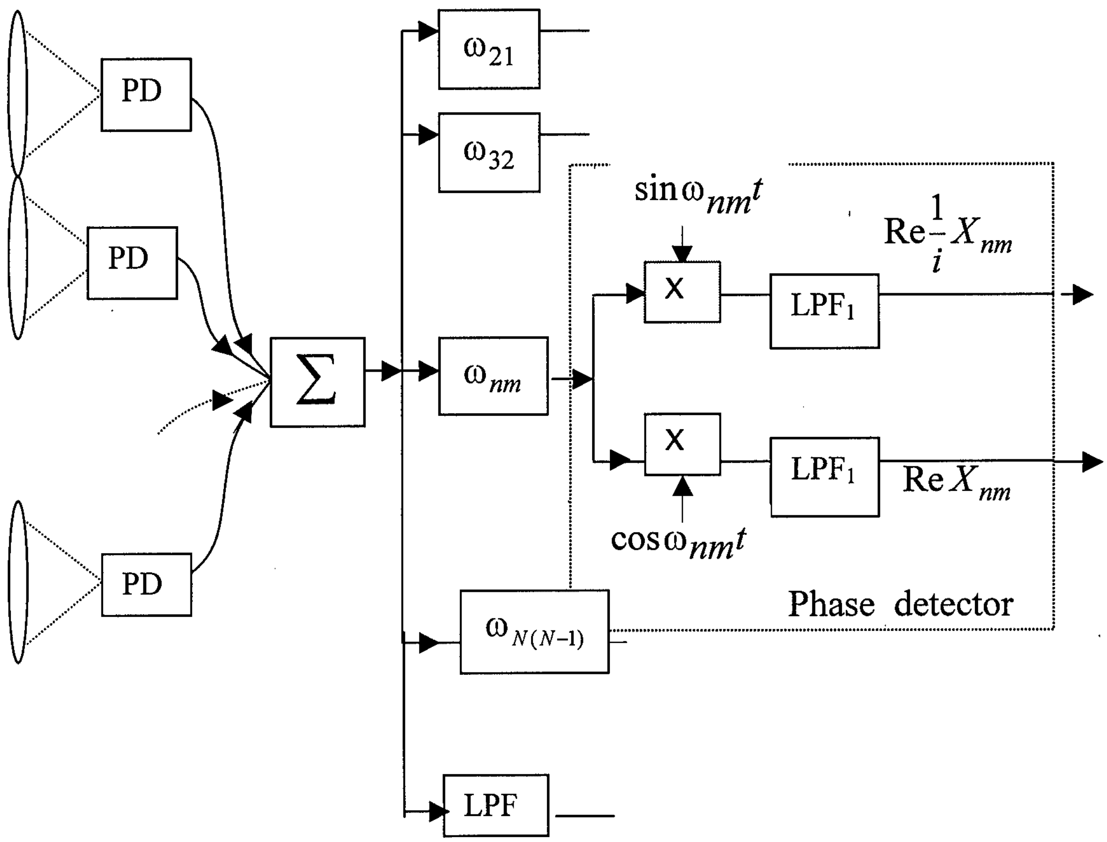

Target
R
$\vec{\rho}_n$
$\vec{\rho}_m$
Transmitters
Receiving telescopes

Fig.1



undergraund
surface
roughness
$\vec{r}_\Sigma$
$\vec{\xi}(\vec{r})$
$\vec{N}$
$\vec{R}$
$|\vec{R}+\vec{r}_\Sigma+\vec{N}\xi-\vec{\rho}_n|$
$|\vec{R}+\vec{r}_\Sigma+\vec{N}\xi-\vec{\rho}|$
$\vec{\rho}_n$
Transmitter
Receiving
Aperture

Fig.2



PD-photodetector,
Σ- summator,
ω_{nm}-bandpass filter tuned to friquency ω_{nm},
LPF, LPF_1 - low pass filtrs.

Fig. 3

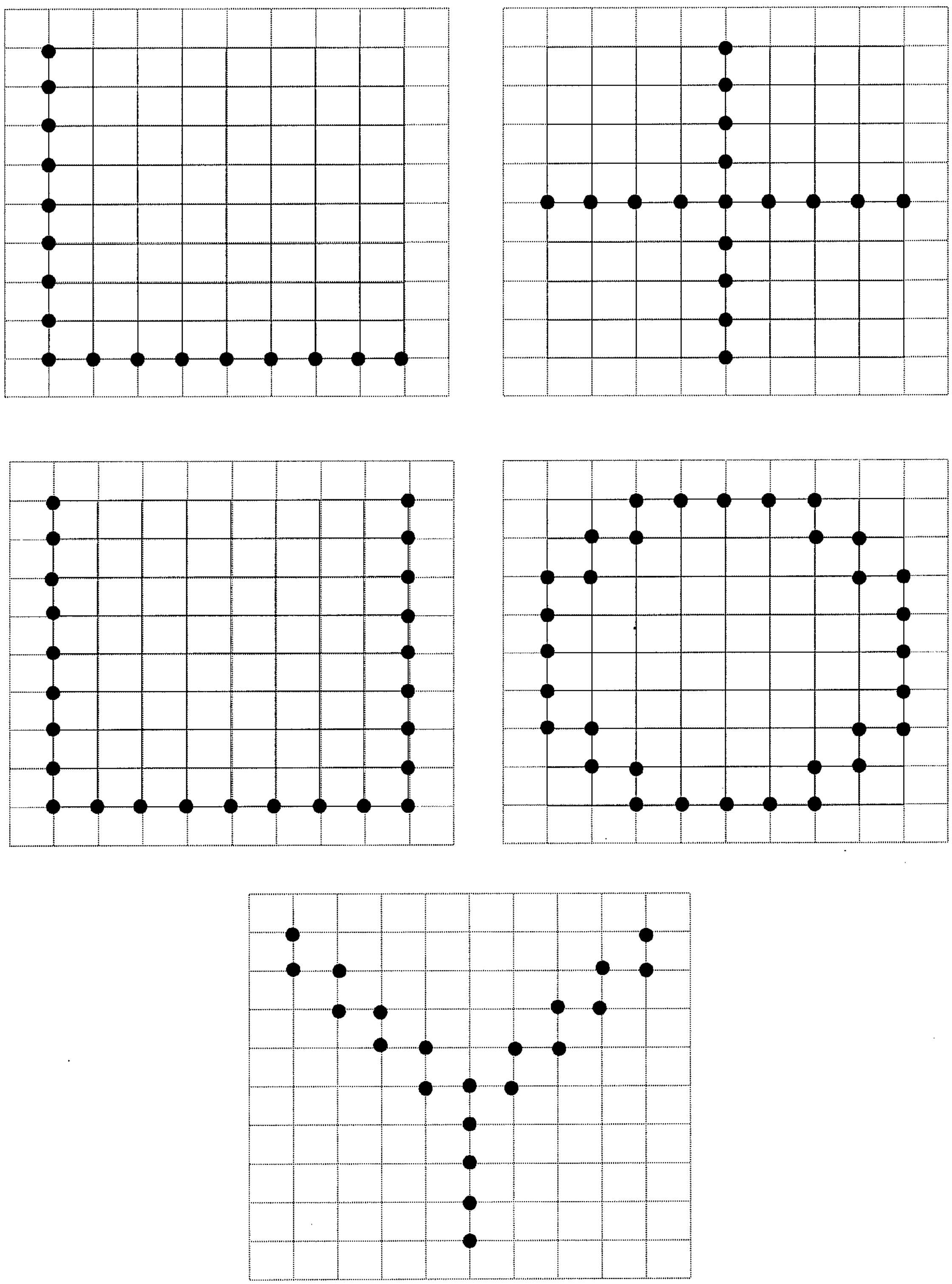


Fig.4

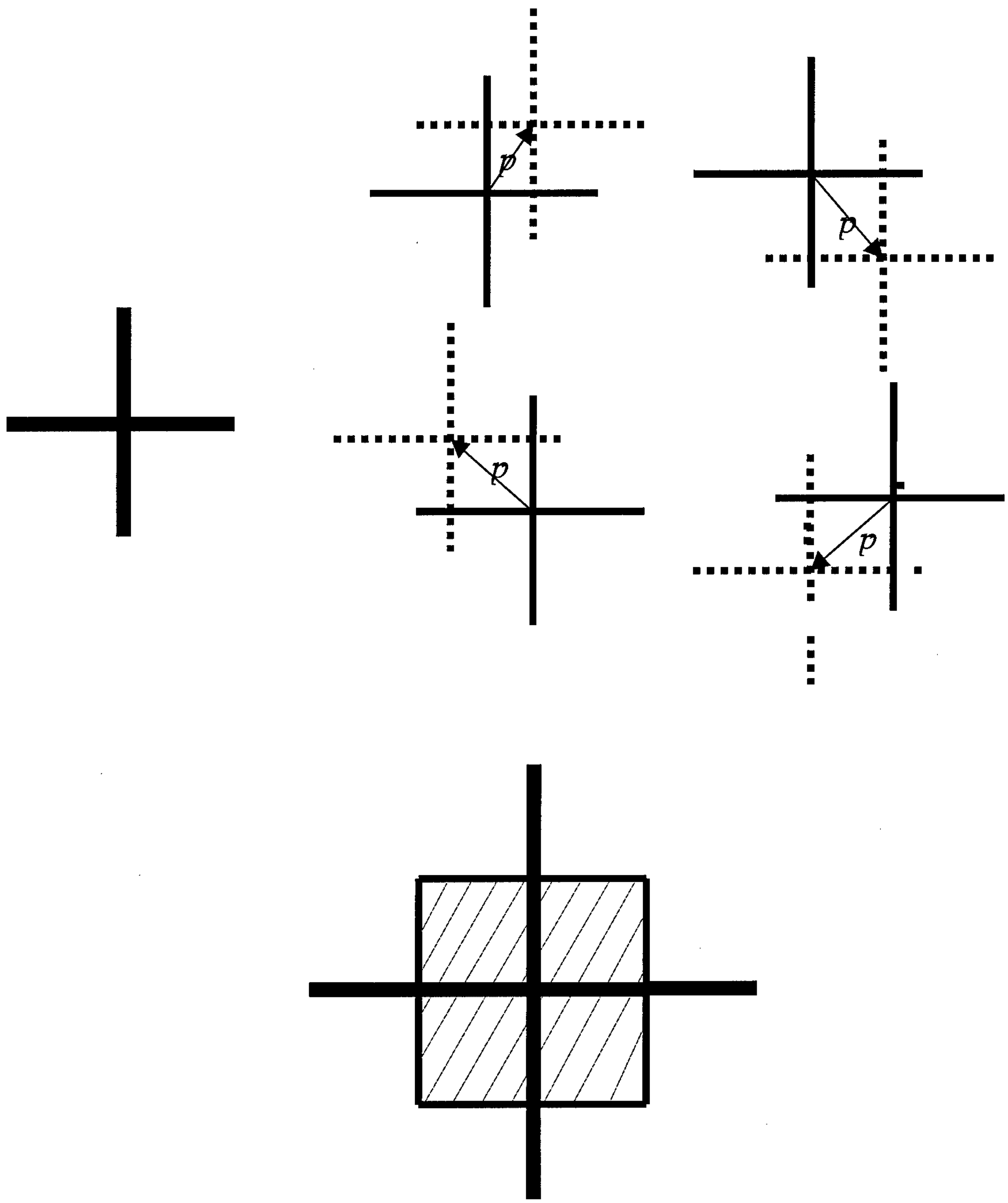


Fig.5a. Fillness of friquency plane
at +-configuration

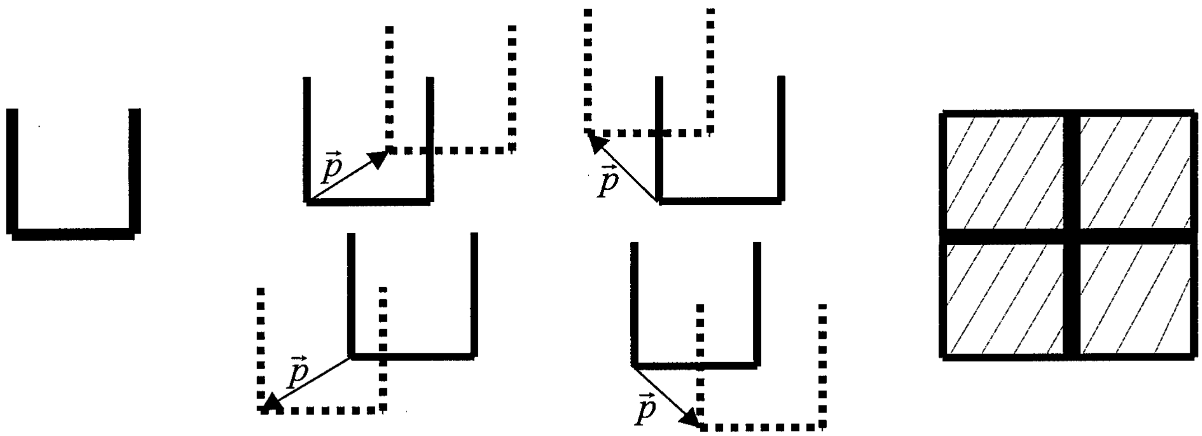


Fig.5b. Fillness of friquency plane
at |_|-configuration

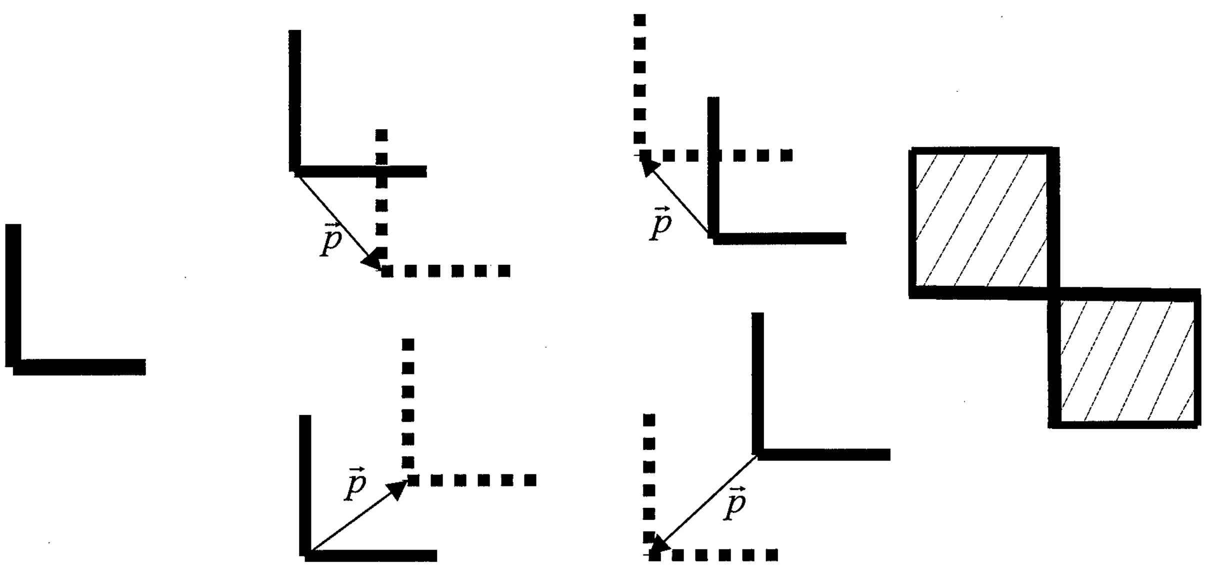


Fig.5b. Fillness of friquency plane
at L-configuration

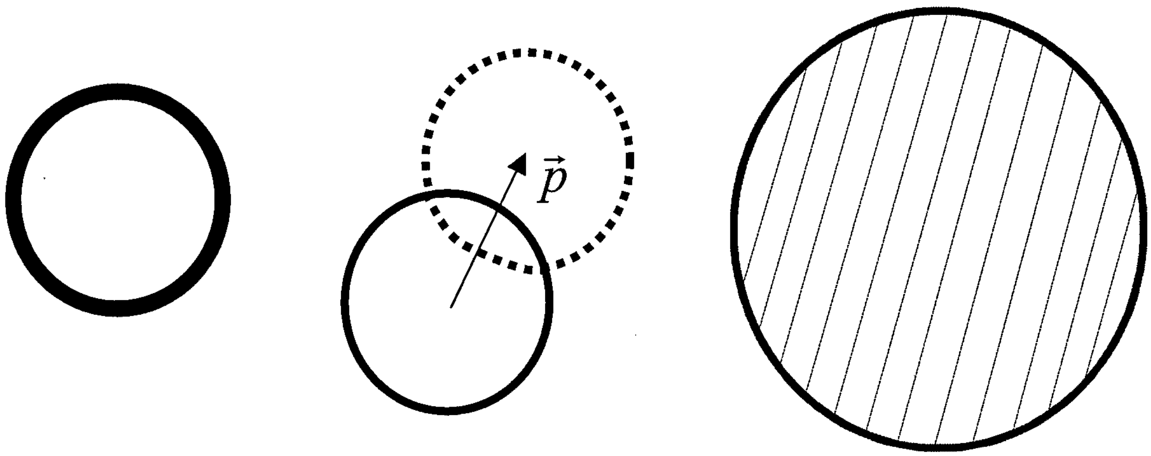


Fig.5d. Fillness of friquency plane at O-configuration

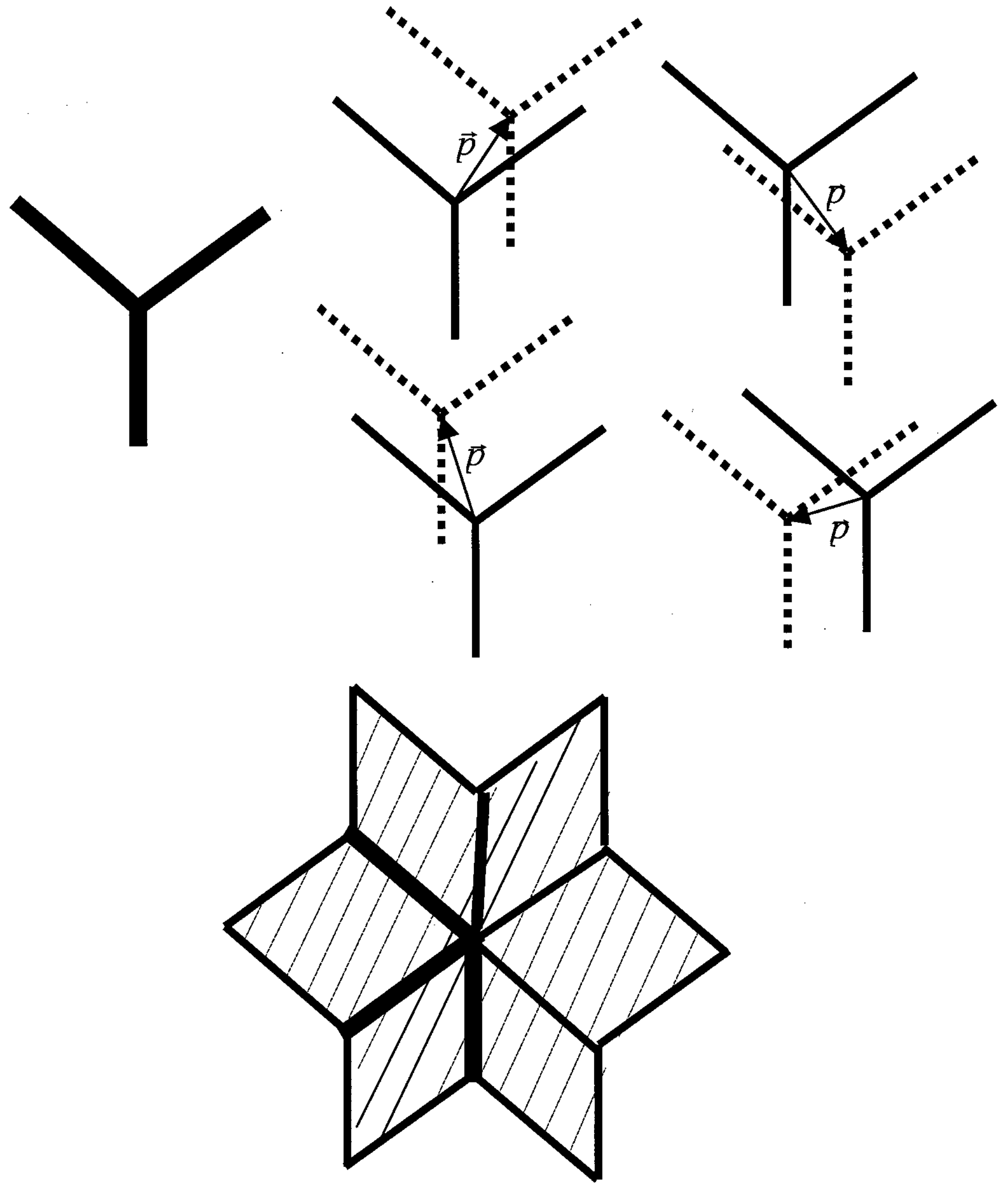


Fig.5e. Fillness of friquency
plane at Y-configuration