



International
Scientific Conference



Algebraic and Geometric Methods of Analysis



Devoted to 160 anniversary of
Dvytro Grave
(25.08.1863 - 19.12.1939)
Academician of the Ukrainian
Academy of Sciences, the
first director of the Institute of
Mathematics of NAS of Ukraine

May 29 – June 1, 2023
Odesa, Ukraine

LIST OF TOPICS

- Algebraic methods in geometry
- Differential geometry in the large
- Geometry and topology of differentiable manifolds
- General and algebraic topology
- Dynamical systems and their applications
- Geometric and topological methods in natural sciences
- Geometric problems in mathematical analysis

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Conformal equivalence of 3-webs

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Let 3-web $W_3 \langle \omega_1, \omega_2, \omega_3 \rangle$ defined in a domain D on the conformal plane (\mathbb{R}^2, g) . We say that this 3-web is *regular* in D if in this domain:

- (1) The discriminant

$$\tilde{\Delta} = -4I_2 + I_1^2 + 18I_1I_2 - 4I_1^3 - 27I_2^3$$

differs from zero.

- (2) Invariants

$$I_1 = \frac{J_2}{J_1^2} \quad \text{and} \quad I_2 = \frac{J_3}{J_1^3}$$

are functionally independent in the domain, that is, the differential 2-form $\Omega = dI_1 \wedge dI_2 \neq 0$.

Moreover, invariants I_1, I_2 are coordinates in the domain.

We remark that the elementary symmetric functions

$$\begin{aligned} J_1 &= \lambda_1 + \lambda_2 + \lambda_3, \\ J_2 &= \lambda_1\lambda_2 + \lambda_1\lambda_3 + \lambda_2\lambda_3, \\ J_3 &= \lambda_1\lambda_2\lambda_3 \end{aligned}$$

are S_3 - invariants and $\lambda_1, \lambda_2, \lambda_3$ are positive smooth functions.

Let's number now forms $\omega_1, \omega_2, \omega_3$ in the domain and say that the 3-web is *oriented* in the domain if in this numbering $\omega_1 \wedge \omega_2 = r_{12}\Omega$, where $r_{12} > 0$. In this case we'll scale forms ω_i in such a way, that

$$\omega_1 \wedge \omega_2 = \Omega.$$

In opposite case, we call the 3-web *non-oriented* and scale the 1-forms ω_i in such a way, that

$$\omega_1 \wedge \omega_2 = -\Omega.$$

In these both cases we decompose 1-forms ω_i in the invariant coordinates I_1, I_2

$$\omega_i = \sum_{j=1}^2 w_{ij} dI_j,$$

Then, all functions $w_{ij}, i = 1, 2, 3; j = 1, 2$ are conformal invariants, satisfying the following additional relations

$$\sum_{i=1}^3 w_{ij} = 0, \quad j = 1, 2.$$

Now, let's write down the standard metric tensor g in invariant coordinates as follows

$$g = \sum_{i,j=1}^2 g_{ij} dI_i \otimes dI_j.$$

Remark, that the volume 2-form Ω_g , associated with metric g , is the following

$$\Omega_g = \sqrt{\det \|g_{ij}\|} dI_1 \wedge dI_2.$$

Therefore, the metric tensor

$$\tilde{g} = \frac{g}{\sqrt{\det \|g_{ij}\|}}$$

has the associated volume form $\Omega_{\tilde{g}} = \Omega$.

Finally, we get the following result.

Theorem 1. *Let 3-web $W_3 \langle \omega_1, \omega_2, \omega_3 \rangle$ be regular in a domain D in the conformal plane (\mathbb{R}^2, g) . Then the above functions*

$$w_{ij}, \quad \tilde{g}_{ij} = \frac{g_{ij}}{\sqrt{\det \|g_{ij}\|}}$$

that are components of 1-forms ω_1, ω_2 and the metric tensor \tilde{g} in the invariant coordinates I_1, I_2 , are conformal invariants of plane 3-webs.

Moreover, any two regular 3-webs are conformally equivalent if and only if the corresponding functions w_{ij} and \tilde{g}_{ij} coincide.

The fundamental group of Riemann surface via Riemann's existence theorem

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One of the classical things we learn in any complex analysis course is the structure of the fundamental group of Riemann surfaces that it is given by the following theorem:

Theorem 1. *The fundamental group of Riemann Surfaces of genus g is given by $2g$ generators with one relation :*

$$\prod_{i=1}^g [a_i, b_i] = 1 \tag{1}$$

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