

International
Online Conference



**Algebraic
and Geometric
Methods of Analysis**

dedicate to the memory
of Yuriy Trokhymchuk
(17.03.1928-18.12.2019)

May 25-28, 2021
Odesa, Ukraine

LIST OF TOPICS

- Topological methods in analysis
- Geometric problems of complex and mathematical analysis
- Algebraic methods in geometry
- Differential geometry in the whole
- Geometry and topology of differentiable manifolds
- General and algebraic topology
- Geometric and topological methods in natural sciences

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Morse flows with singularities on boundary of 3-manifolds

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A flow X on a manifold with boundary ∂M is called a *Morse flow* if it satisfies the following conditions:

- (1) the set of non-wandering points $\Omega(X)$ has a finite number of points that all are hyperbolic;
- (2) if $u, v \in \Omega(X)$, then the unstable manifold $W^u(u)$ is transverse to the stable manifold $W^s(v)$ in $\text{Int}M$;
- (3) the restriction of X to ∂M is a Morse flow (the stable and unstable manifolds have a transversal intersection).

We consider Morse flows with singularities on ∂M . There are 6 types of singularities which are determined by their indices.

The pair (p, q) is called the index of a singular point where $p + q$ is equal to dimension of stable manifold of X and p is the dimension of the flow restricted to the boundary. In this case $p = 0, 1$ or 2 and $q = 0$ or 1 . For example, a source has index $(0,0)$ and a sink has index $(2,1)$.

The surface F is the closure of intersection of $\text{Int} M$ with boundary of a regular neighborhood for the union of the 1-dimensional stable manifolds.

Arcs and circles $\{u, U, v, V\}$ on F are intersections of unstable manifolds for singular points of index $(1,0), (0,1), (1,1), (2,0)$ and the surface F .

The set (F, u, U, v, V) consisting of a surface with boundary, a set of circles and arcs embedded in it as described above is called a Morse flow diagram.

Theorem 1. *Two Morse-Smale flows on 3-manifold with a boundary are topologically trajectory equivalent if and only if their diagrams are homeomorphic.*

Morse flow diagrams have the following properties:

- (1) $U_i, V_i \subset \text{Int}M, \text{Int}u_i, \text{Int}v_i \subset \text{Int}M, \partial u_i, \partial v_i \subset \partial M$;
- (2) $\partial U_i \partial \cup_i u_i, \partial V_i \partial \cup_i v_i$;
- (3) $U_i \cap U_j = \emptyset$ if $i \neq j, u_i \cap u_j = \emptyset$ if $i \neq j, V_i \cap V_j = \emptyset$ if $i \neq j, v_i \cap v_j = \emptyset$ if $i \neq j, u_i \cap U_j = \emptyset, v_i \cap V_j = \emptyset, \partial u_i \cap \partial v_j = \emptyset$.
- (4) U_k is a closed curve or it belongs to a left-hand turn cycle which consists of U_i and u_j ; the similar property holds true for V_k .
- (5) if we cut F along u_i and do spherical surgeries by U -cycles then we get a union of 2-disks.

Theorem 2. *If a surface F with 4 sets of curves has the properties 1-5, then it is a diagram of a Morse flow.*

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