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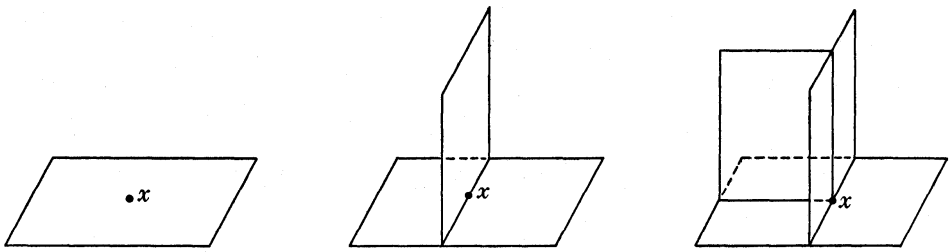
Flows and Spines

Ippei ISHII

Keio University

Introduction

A compact two dimensional polyhedron P is called a *closed fake surface* (See [3].), if each point x of P has a regular neighborhood homeomorphic to one of the following three types described in Figure 1.



Type-1 Type-2 Type-3

FIGURE 1

For a closed fake surface P, define

$$\mathfrak{S}_i'(P)=\{x\in P \mid \text{the regular neighborhood of } x \text{ is of type-}i\} \quad (i=1, 2, 3)\ .$$

The i-th singularity $\mathfrak{S}_i(P)$ is defined to be the closure of $\mathfrak{S}_i'(P)$ in P. A closed fake surface P is called a *standard spine* of a closed 3-manifold M, if it is embedded in M and $M-N(P)$ is homeomorphic to a 3-ball ($N(P)$ denotes a regular neighborhood of P in M). It is known ([2]) that any closed 3-manifold has a standard spine.

In this paper, we introduce a restricted class of standard spines, which we call flow-spines. In § 1 we first define a "normal pair" which is a pair of a non-singular flow ψ_t on a closed 3-manifold M and its local section Σ. And we will show that a normal pair (ψ_t, Σ) determines flow-spines $P_-(\psi_t, \Sigma)$ and $P_+(\psi_t, \Sigma)$. Moreover it will be shown that on any closed 3-manifold there exists a normal pair. In §§ 2–4, we will exhibit methods for deciding the orientability and the fundamental group of the

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