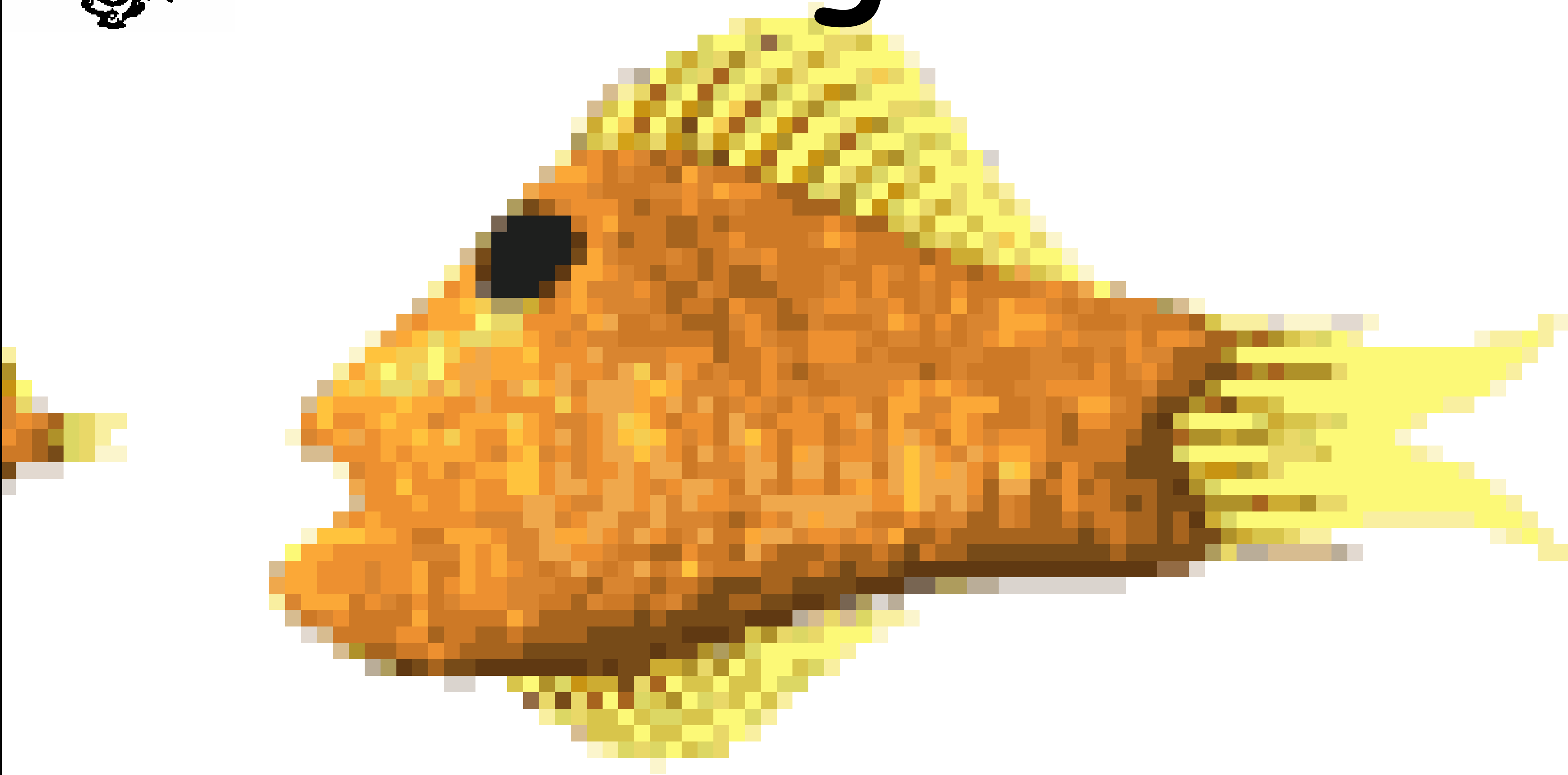
ESCOLA POLITÉCNICA DA UNIVERSIDADE DE SÃO PAULO

divergente



A.G. Antunha

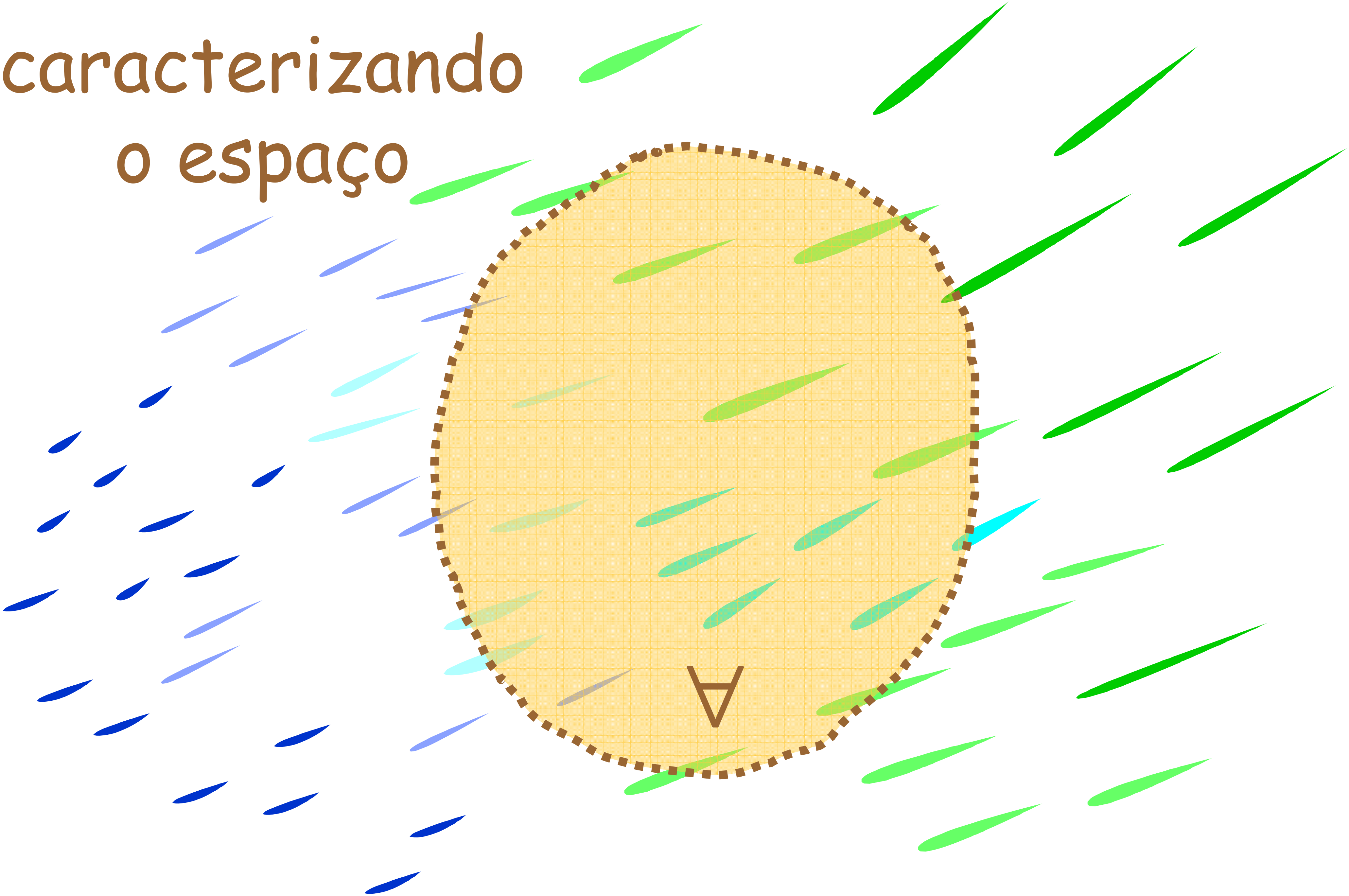
objetivo:

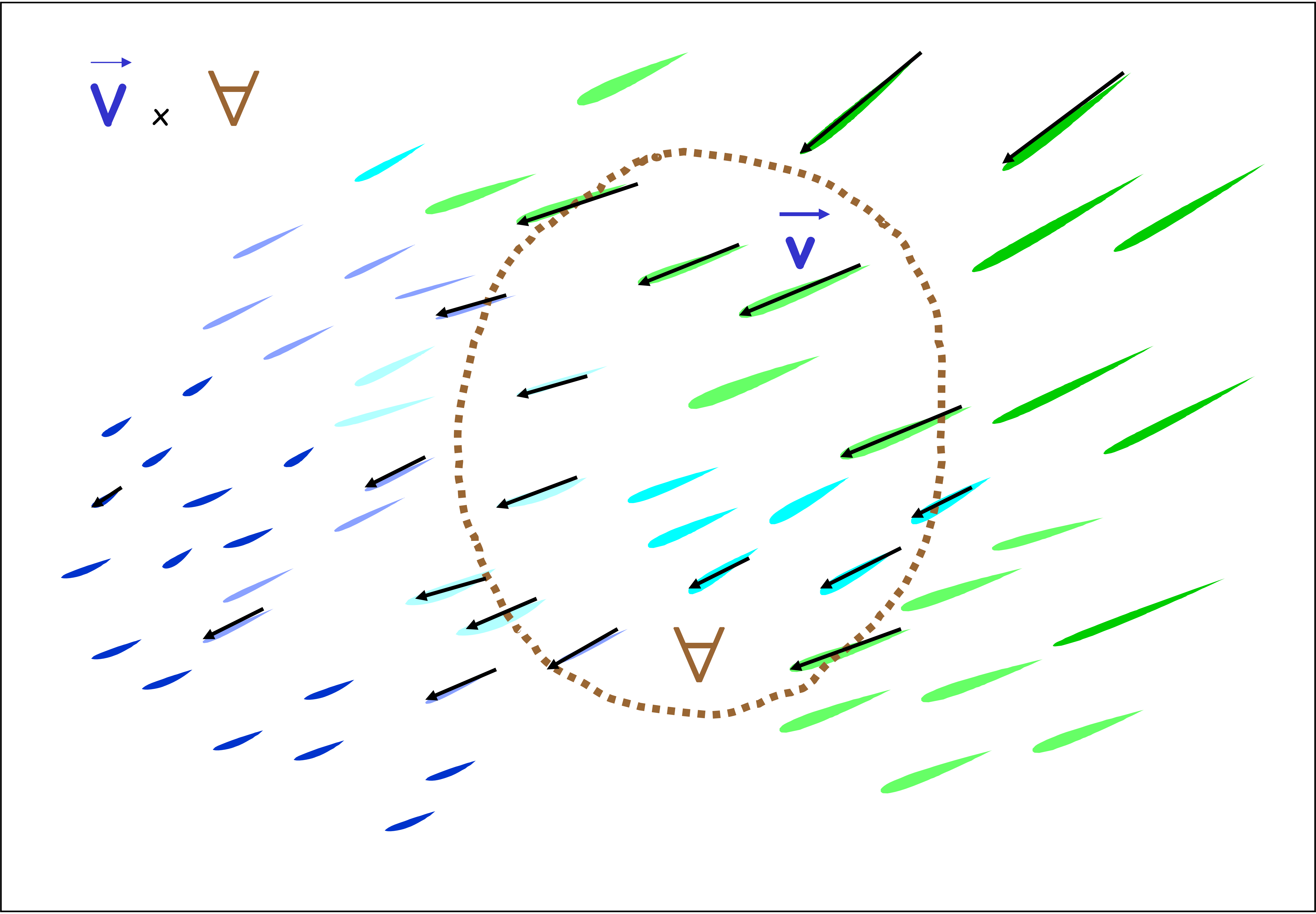
representar a
<u>variação</u> de um
campo vetorial
no espaço

um instantâneo

caracterizando um campo vetorial $\vec{v}$ variável

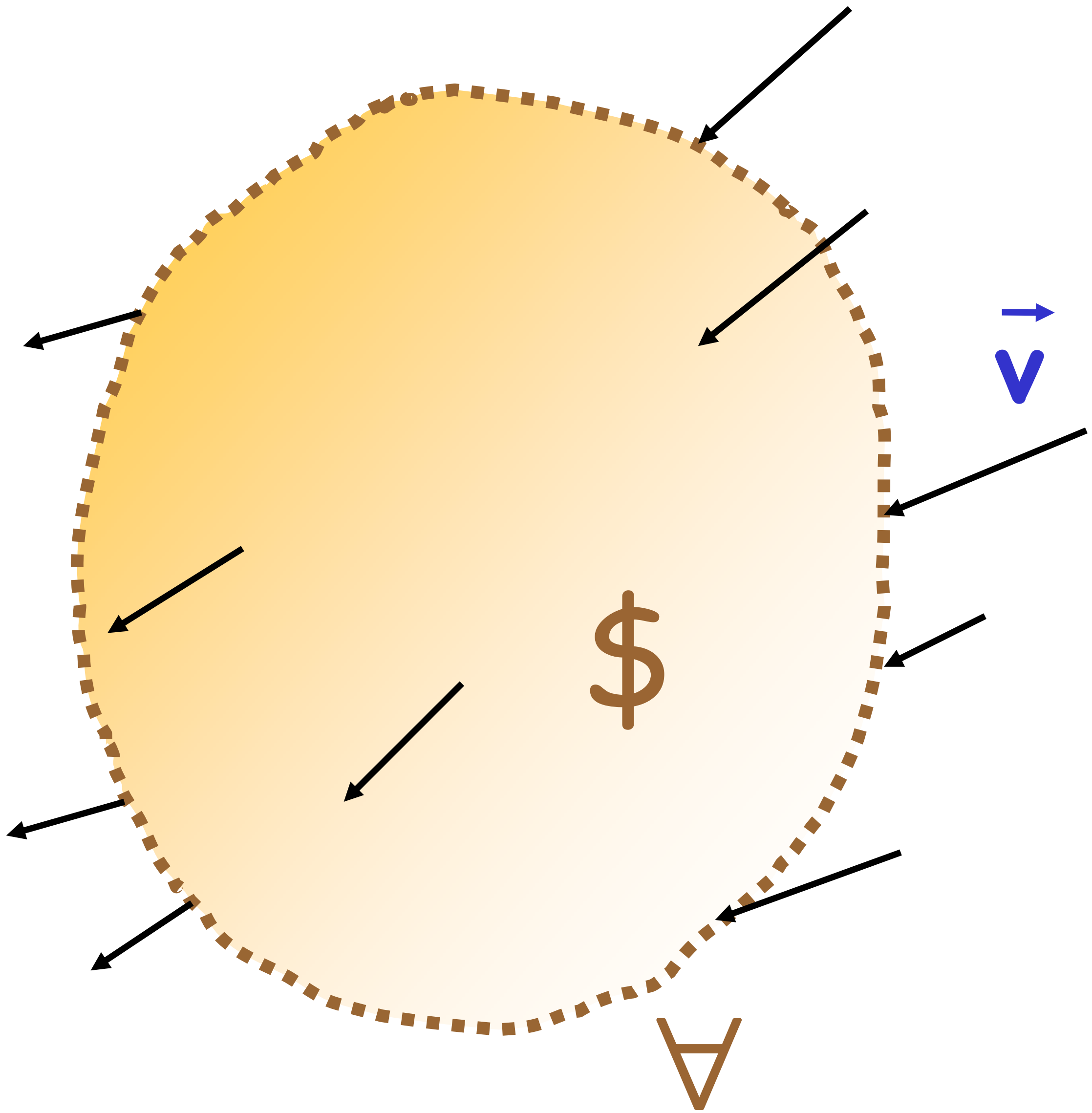
caracterizando o espaço

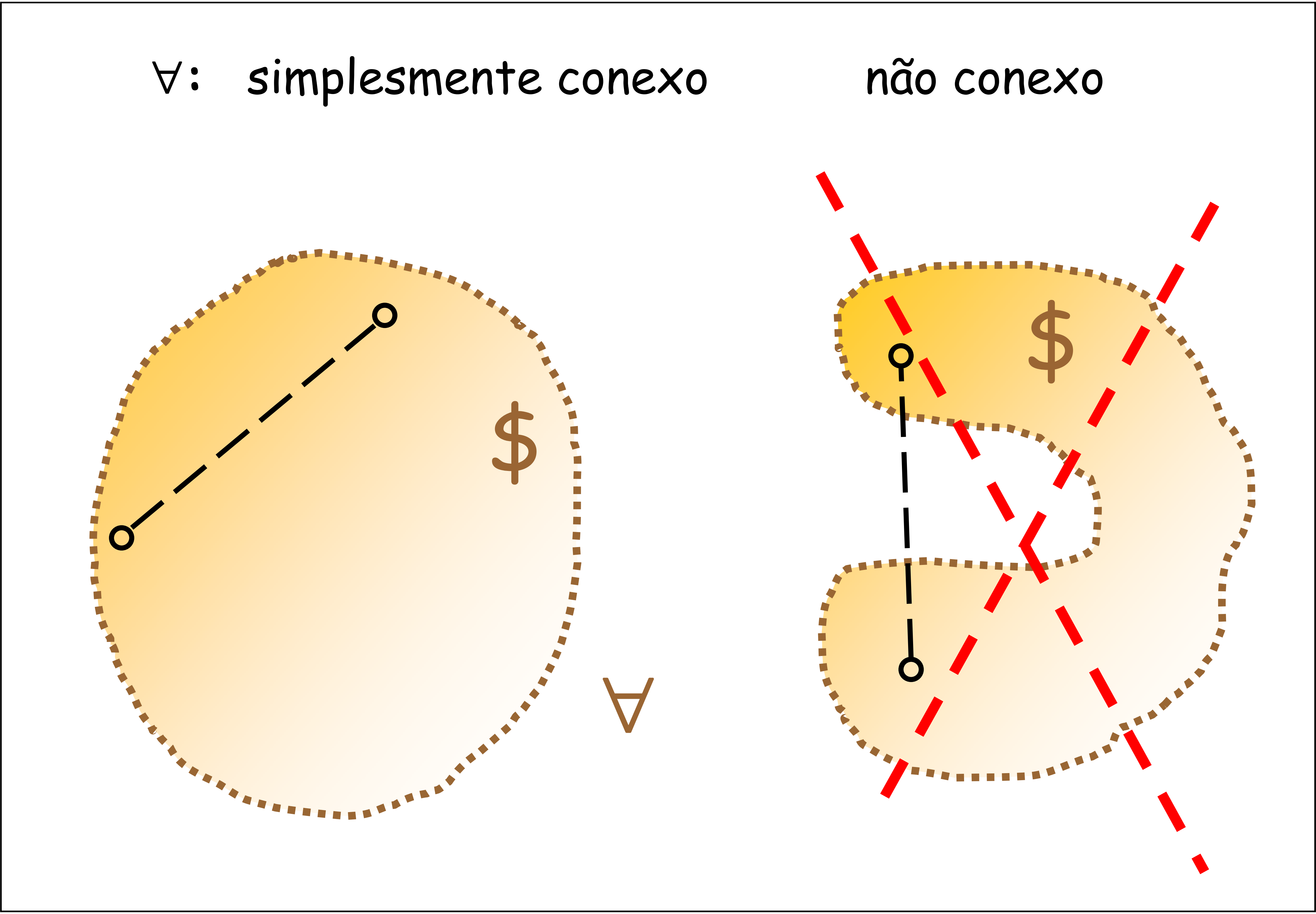




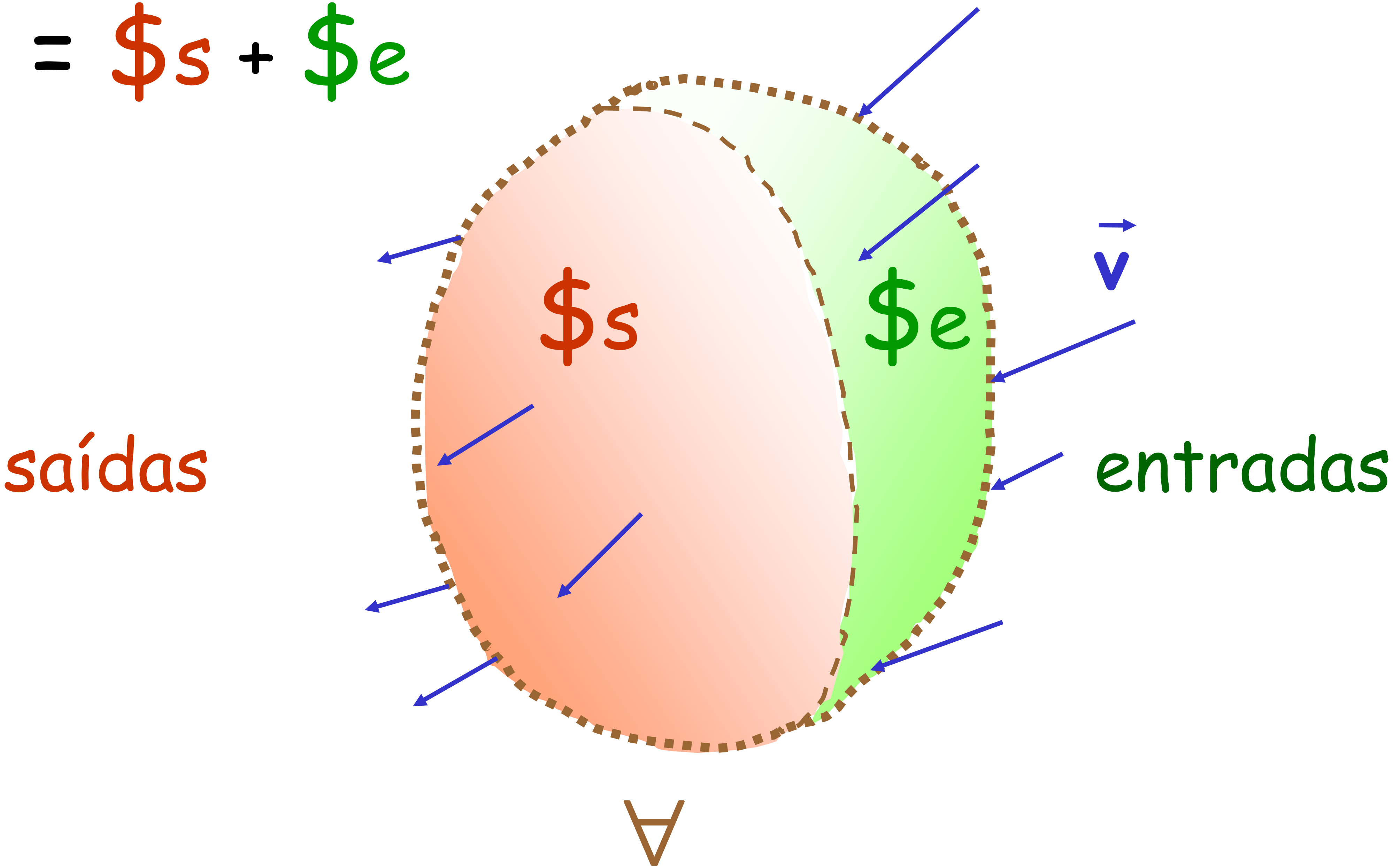
$\vec{V} \times \forall$
$\vec{V}$
$\forall$

examinemos o campo vetorial atravessando a fronteira $

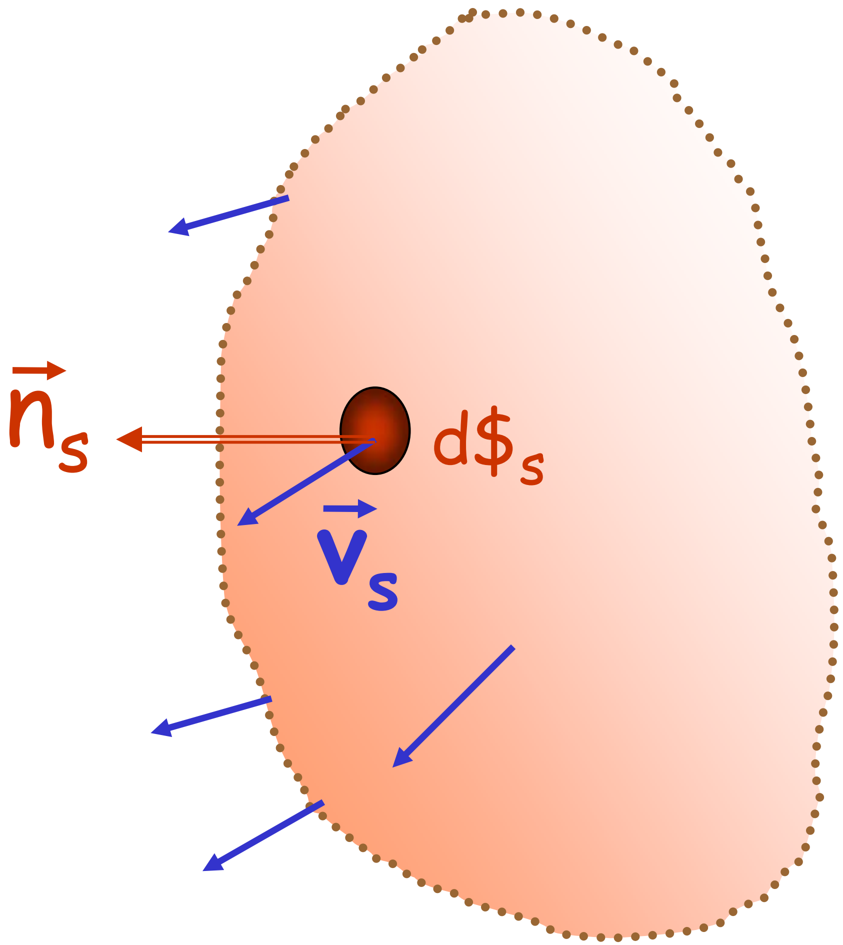


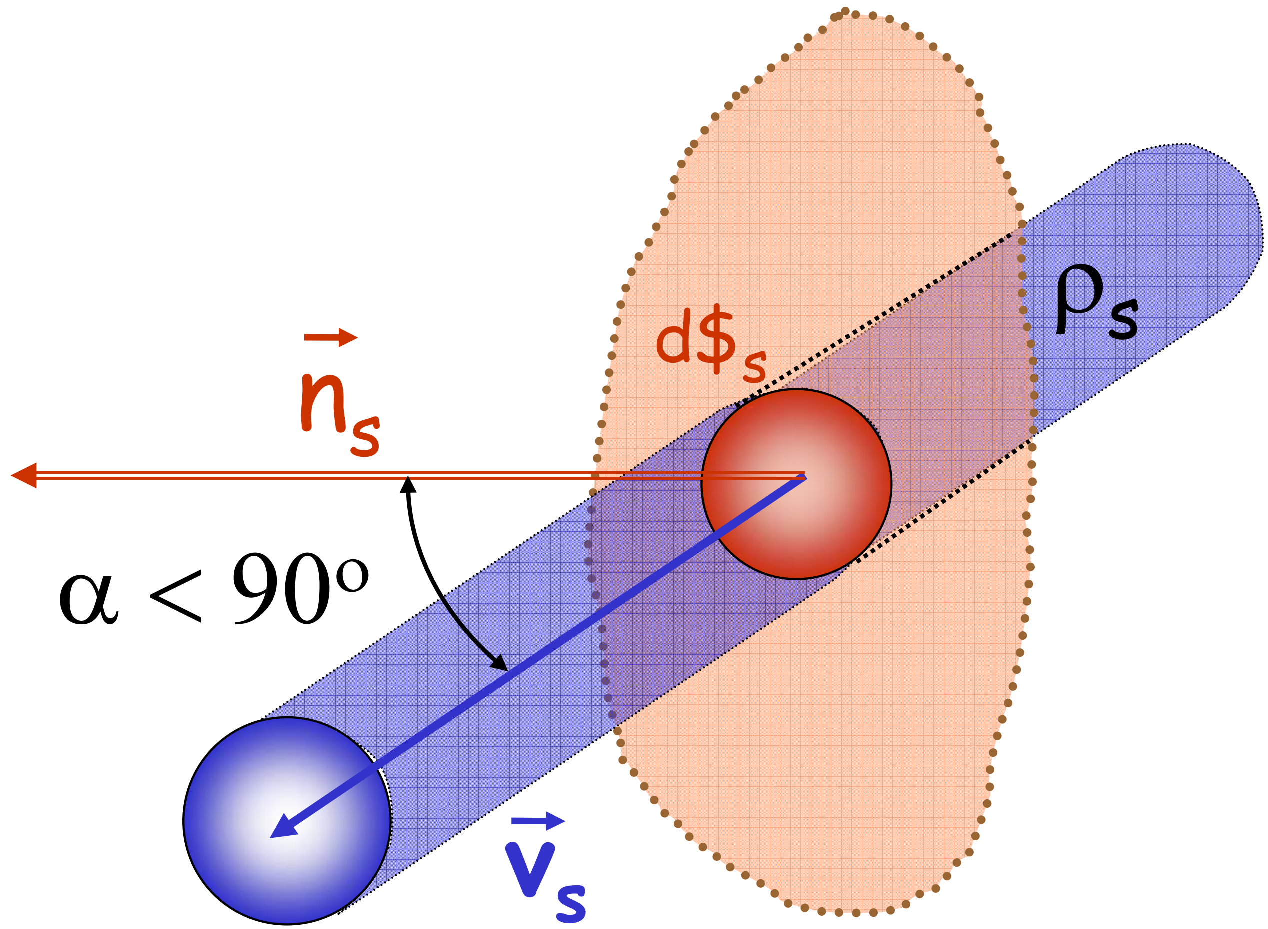

∀: simplesmente conexo
não conexo
$
$
∀

$\$ = \$s + \$e$



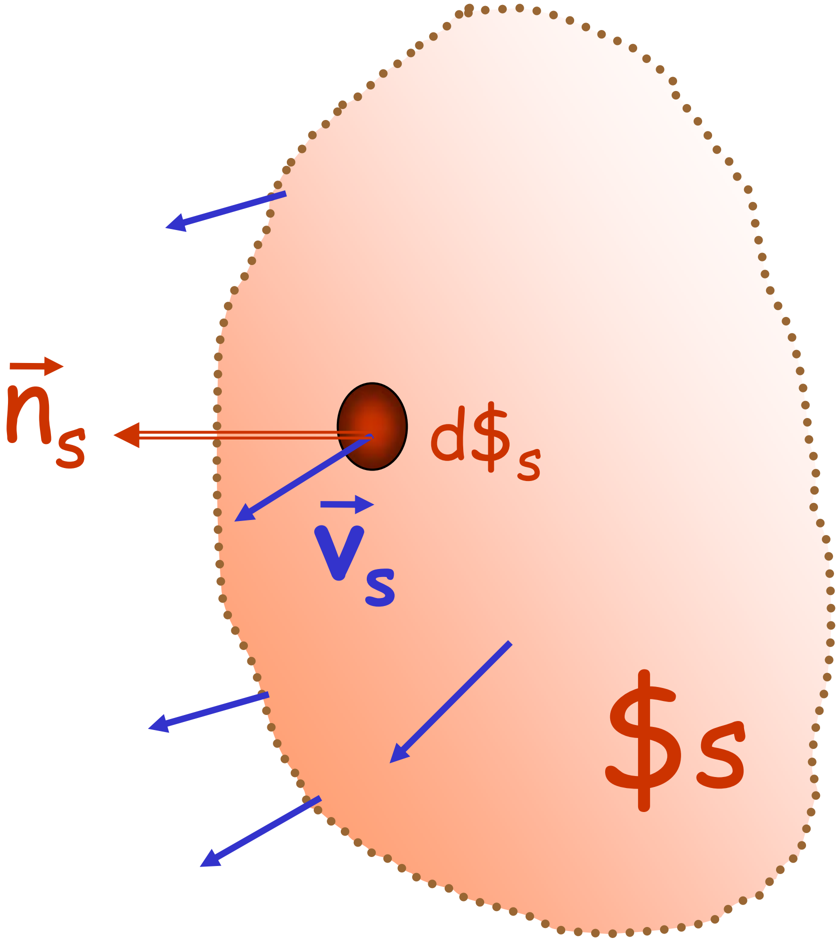
$s -> d$s





$$\delta \dot{m}_s = \rho_s \, \vec{v}_s \, . \, \vec{n}_s \, d\$_s =$$

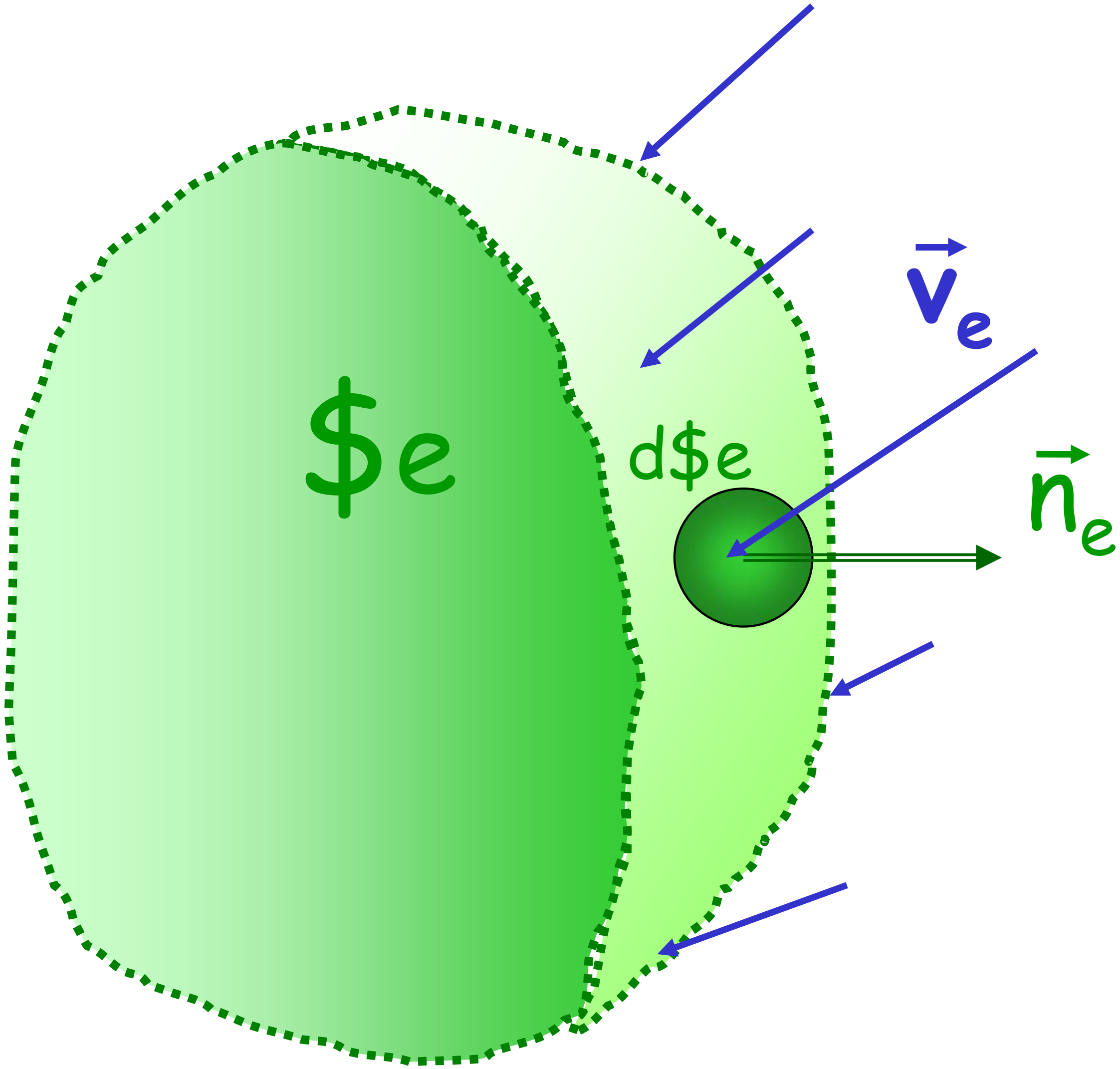
$$= \rho_s \, v_s \cos \alpha \, d\$_s$$



$$\delta\, \dot{m}_s = \rho_s\, \vec{v}_s \,.\, \vec{n}_s\, d\$_s$$

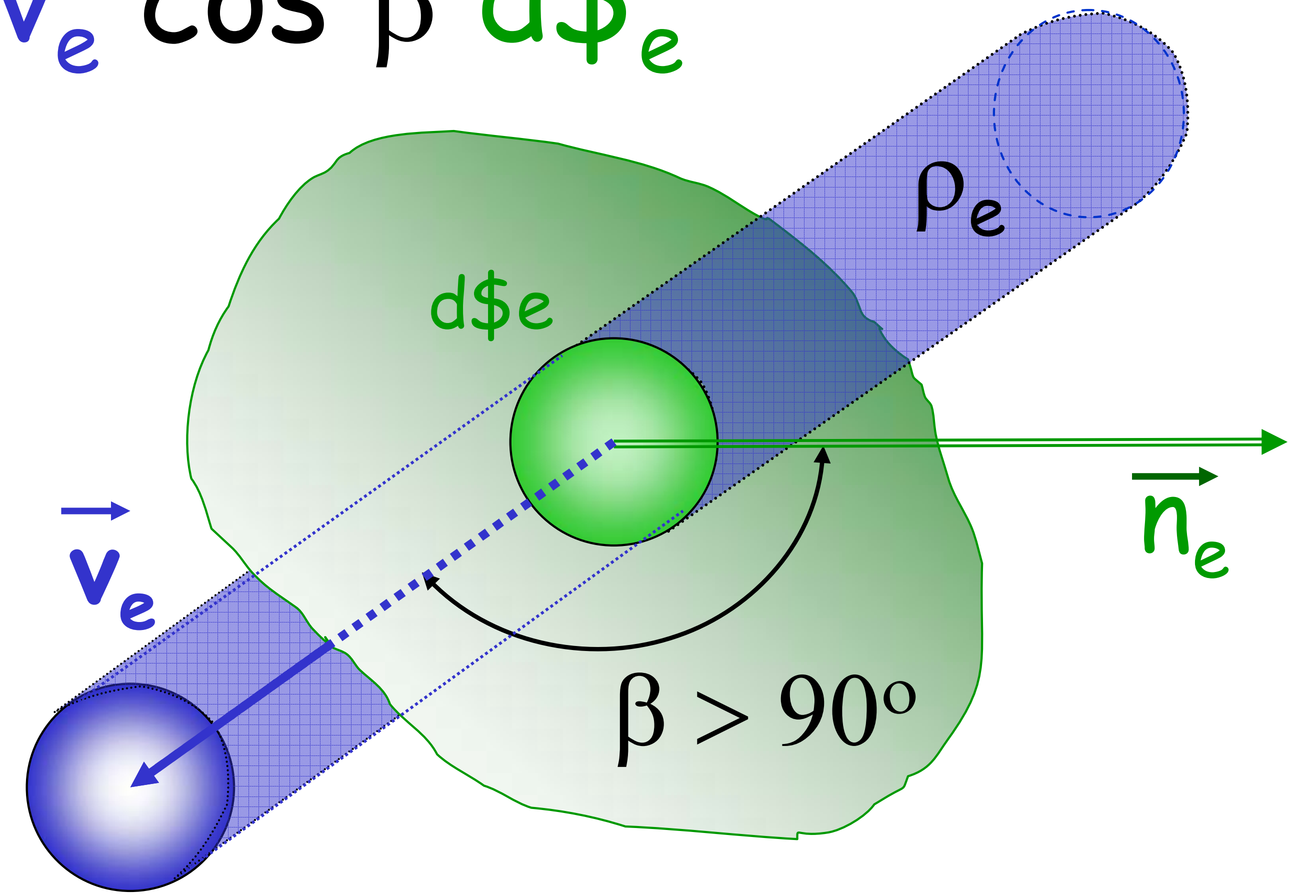
$$\dot{m}_s = \int_{\$_s} \delta\, \dot{m}_s = \int_{\$_s} \rho_s\, \vec{v}_s \,.\, \vec{n}_s\, dS$$

$Se \rightarrow dSe$

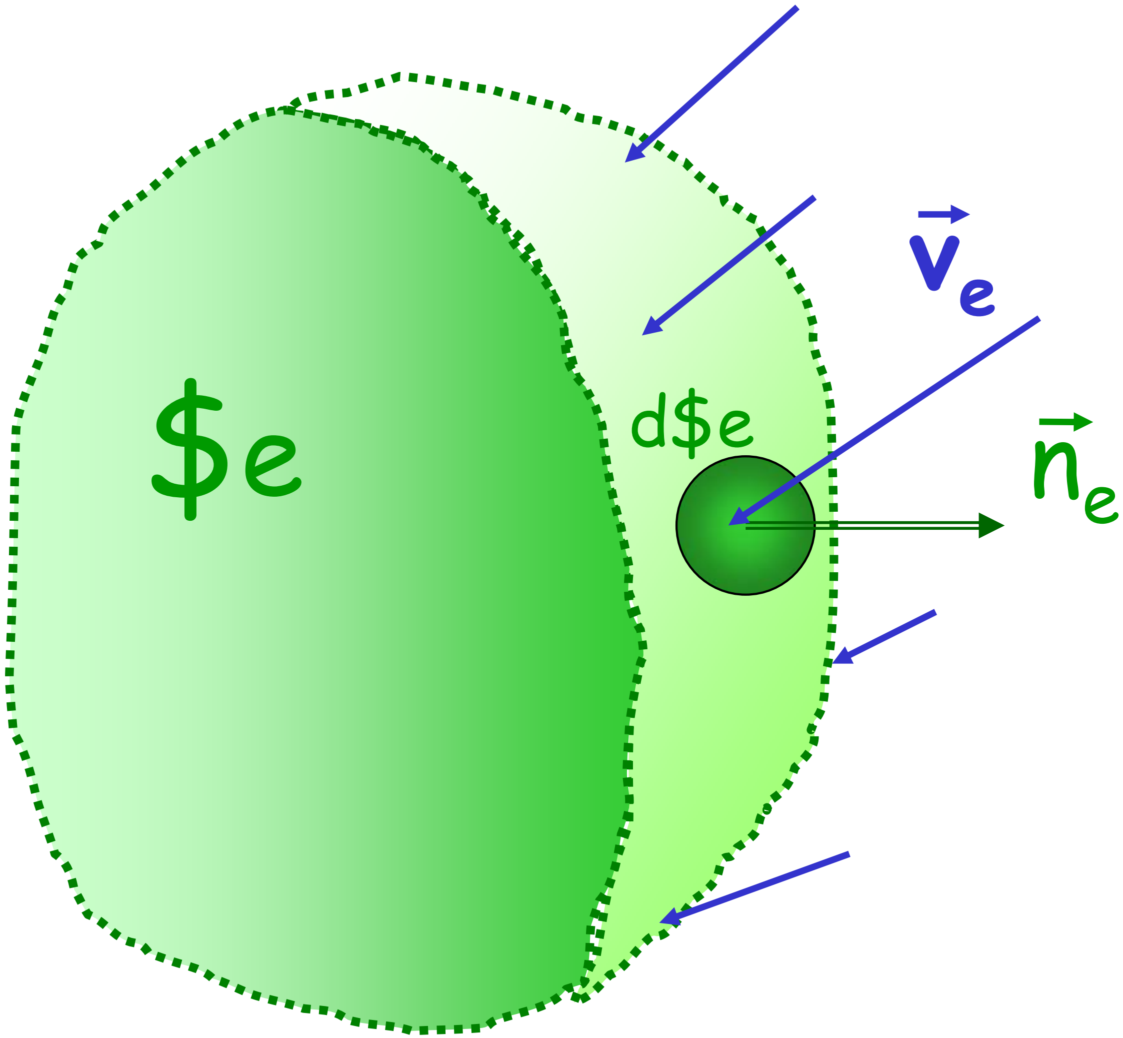


$$\delta \dot{m}_e = - \rho_e \, \vec{v}_e \cdot \vec{n}_e \, d\$_e =$$

$$= - \rho_e \, v_e \cos\beta \, d\$_e$$

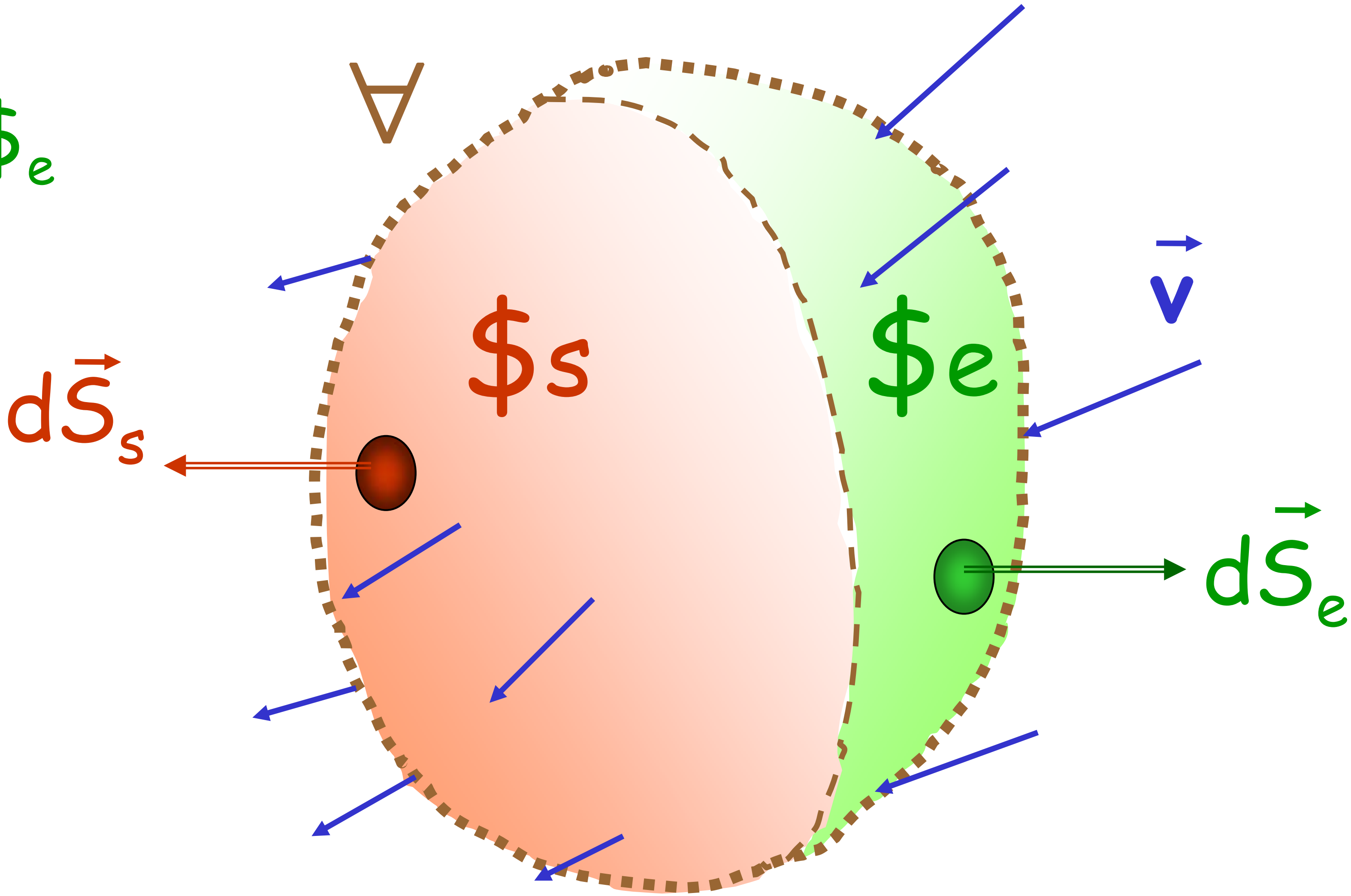


$$\delta\,\dot{m}_e = -\ \rho_e\,\vec{v}_e\,.\,\vec{n}_e\,d\$_e$$



$$\dot{m}_e = \int_{\$_e} \delta\,\dot{m}_e = \int_{\$_e} -\rho_e\,\vec{v}_e\,.\vec{n}_e\,dS$$

$$\$ = \$_s + \$_e$$



$$\dot{m}_e - \dot{m}_s = \int_{\$_e} -\rho_e\, \vec{v}_e \,.\, d\vec{S}_e - \int_{\$_s} \rho_s\, \vec{v}_s \,.\, d\vec{S}_s$$

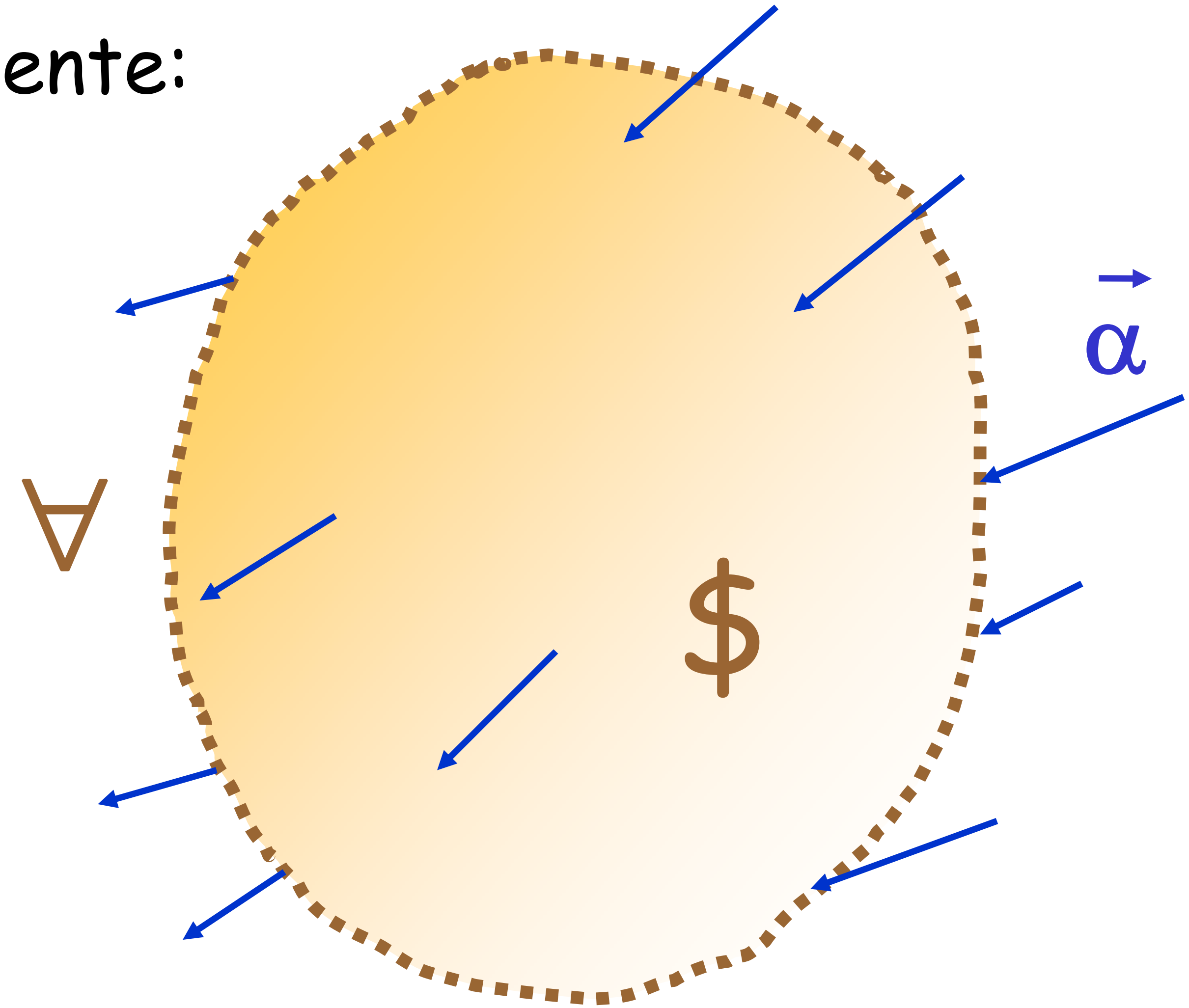
$$\dot{m}_e - \dot{m}_s = \int_{\$_e} -\rho_e \vec{v}_e . \vec{n}_e \, dS - \int_{\$_s} \rho_s \vec{v}_s . \vec{n}_s \, dS$$

$$\dot{m}_e - \dot{m}_s = -\int_{\$_e + \$_s} \rho \vec{v} . \vec{n} \, dS$$

balanço de chuva em $\forall$:

$$\boxed{\dot{m}_e - \dot{m}_s = -\int_{\$} \rho \vec{v} . \vec{n} \, dS}$$

definição de divergente:



$$\int_{\$} \vec{\alpha}.\vec{n}\, dS = \int_{\forall} \mathrm{div}\, \vec{\alpha}\, dV$$

balanço de chuva em $:

$$\dot{m}_e - \dot{m}_s = -\int_{\$} \rho \vec{v}.\vec{n}\, dS$$

definição de divergente:

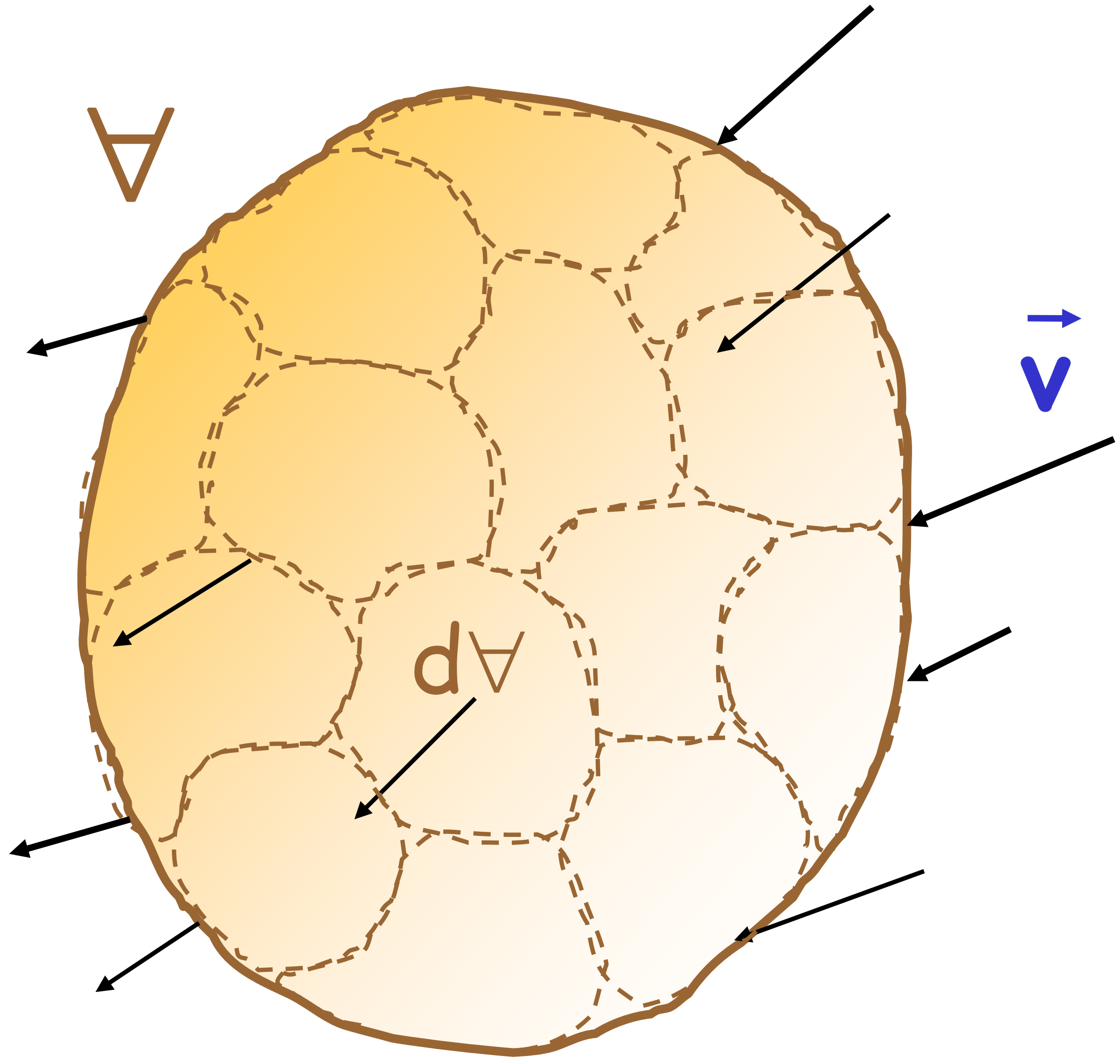
$$\int_{\$} \vec{\alpha}.\vec{n}\, dS = \int_{\forall} \mathrm{div}\,\vec{\alpha}\, dV$$

balanço de chuva em $\forall$:

$$\dot{m}_e - \dot{m}_s = -\int_{\forall} \mathrm{div}(\rho \vec{v})\, dV$$

$d\forall$

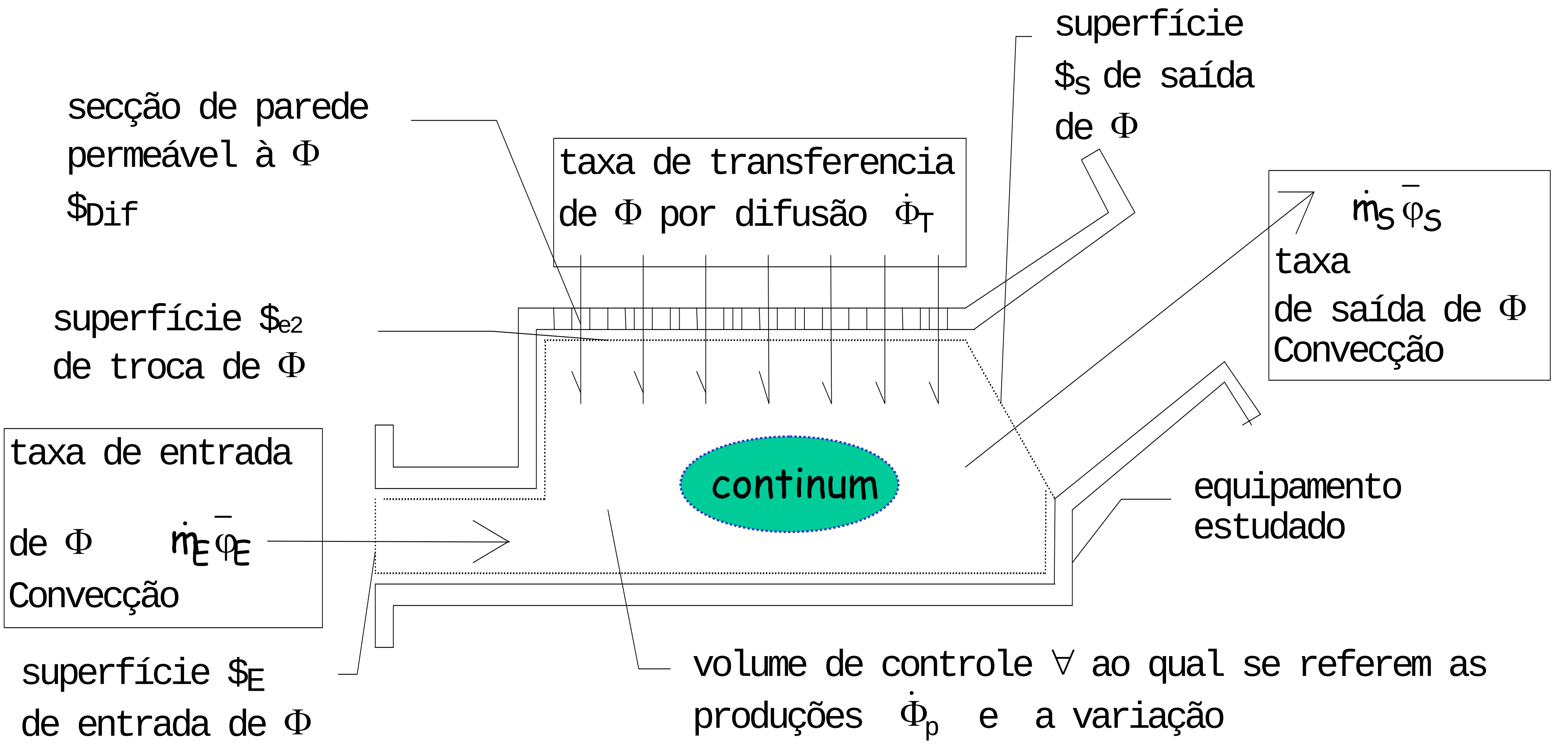
$$\delta \dot{m} = - \; \mathrm{div}(\rho \vec{v})$$



$\forall$

$$\dot{m}_e - \dot{m}_s = - \int_{\forall} \mathrm{div}(\rho \vec{v}) \, dV$$

$$\frac{\partial\left(m\bar{\varphi}\right)}{\partial t} = \bar{\varphi}_E\,\dot{m}_E - \bar{\varphi}_S\,\dot{m}_S + \dot{\Phi}_D + \dot{\Phi}_P$$



$$\rho \frac{D\varphi}{Dt} = \frac{\partial \rho\varphi}{\partial t} + \operatorname{div} \rho\vec{v}\,\varphi = -\operatorname{div}\vec{j}_{\Phi} + \dot{\sigma}_{\forall\Phi}$$