# Introduction to
# RADAR POLARIMETRY

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*Course Material available at http://earth.esa.int/landtraining07/*
*(courtesy Prof. E.Pottier)*

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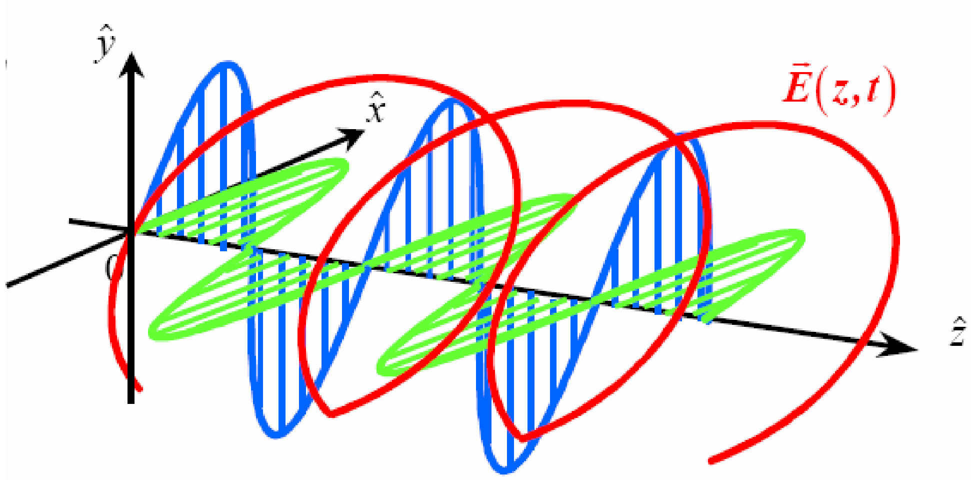
# OUTLINE

1. Introduction
2. Wave Polarimetry
3. Scattering Polarimetry
4. Polarimetric Remote Sensing
5. Thesis Topics

# INTRODUCTION

# INTRODUCTION

## What is Radar Polarimetry

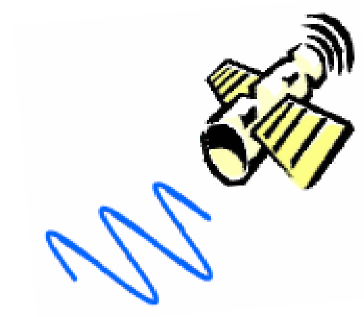



**Radar Polarimetry (Polar : polarisation Metry: measure) is the science of acquiring, processing and analysing the polarization state of an electromagnetic field**

**Radar Polarimetry deals with the full vector nature of polarized electromagnetic waves**

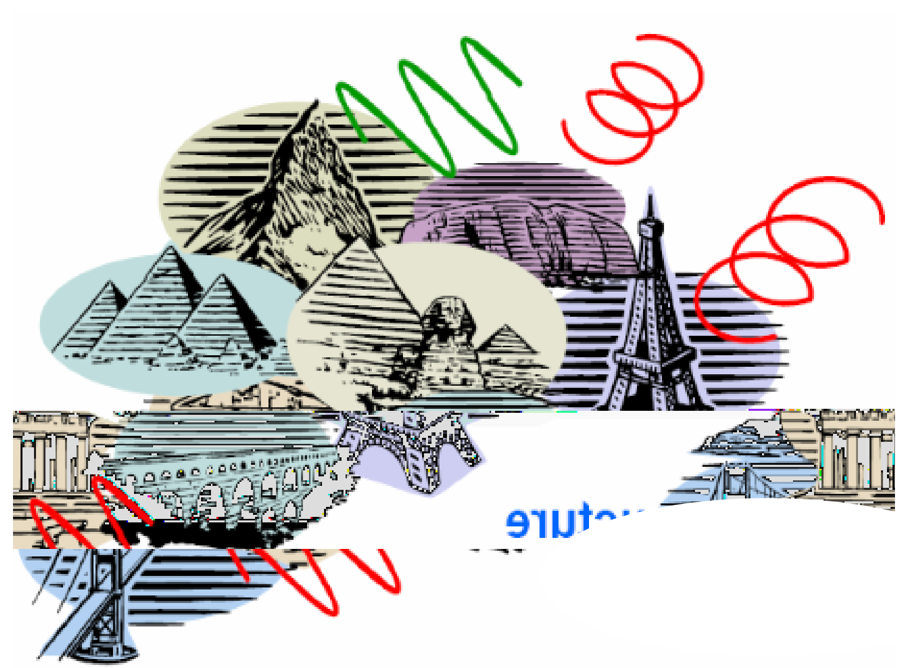
# INTRODUCTION

## What is Radar Polarimetry



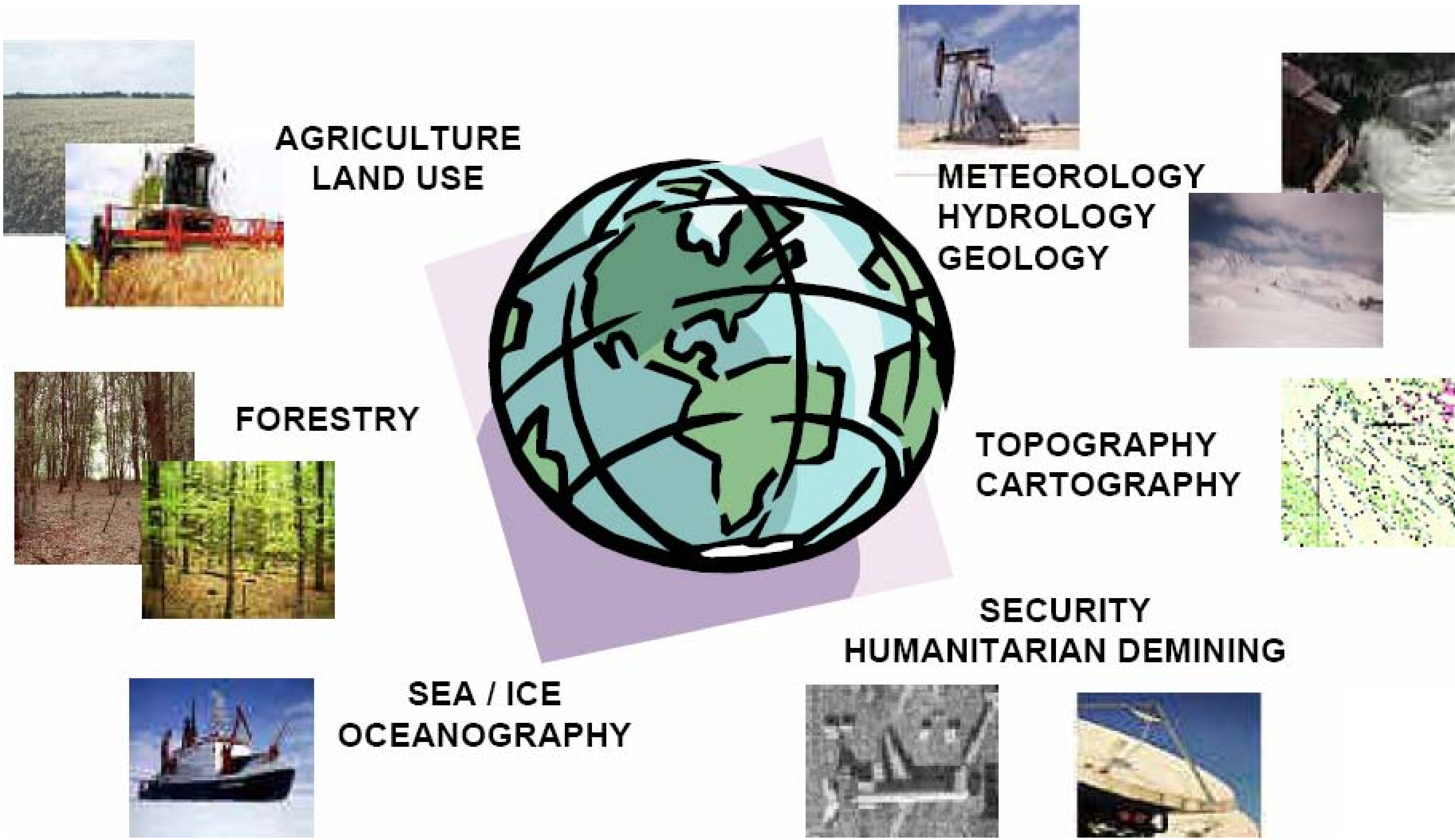
The information contained into backscattered waves from a given target is highly related to:

- → geometrical structure
- → reflectivity
- → shape
- → orientation
- → geophysical properties
- → umidity
- → roughness
- → etc.



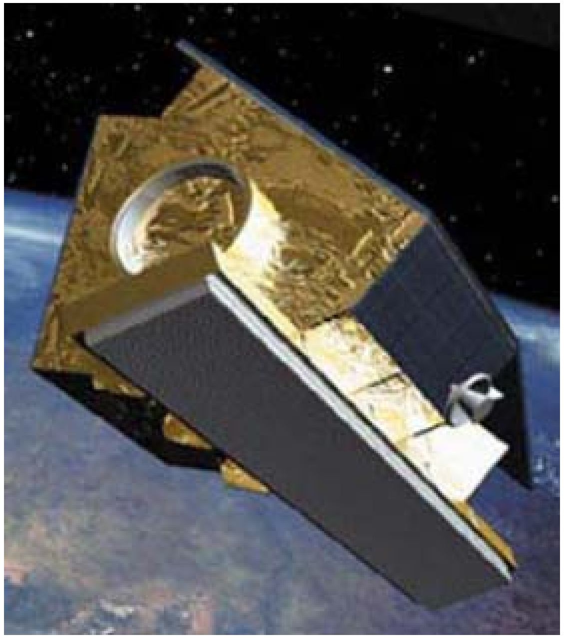
# INTRODUCTION

## Polarimetry and Remote Sensing (EO)



# INTRODUCTION

## Polarimetric Spaceborne SAR Sensors



TERRA SAR

BMBF / DLR / ASTRIUM

June 2007

X-band

L-band (Twin satellite)


ALOS PALSAR

NASDA / JAROS (J)June Jan 2006

L-band

RADARSAT-2

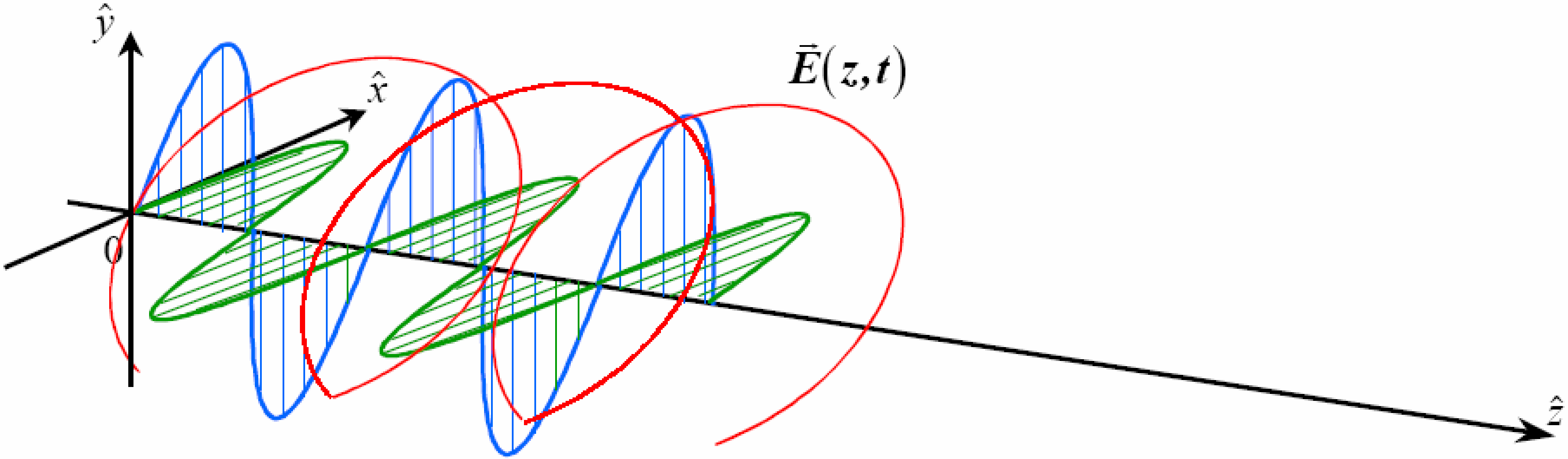
CSA / MDA (CA)

Dec 2007

C-band

# WAVE POLARIMETRY

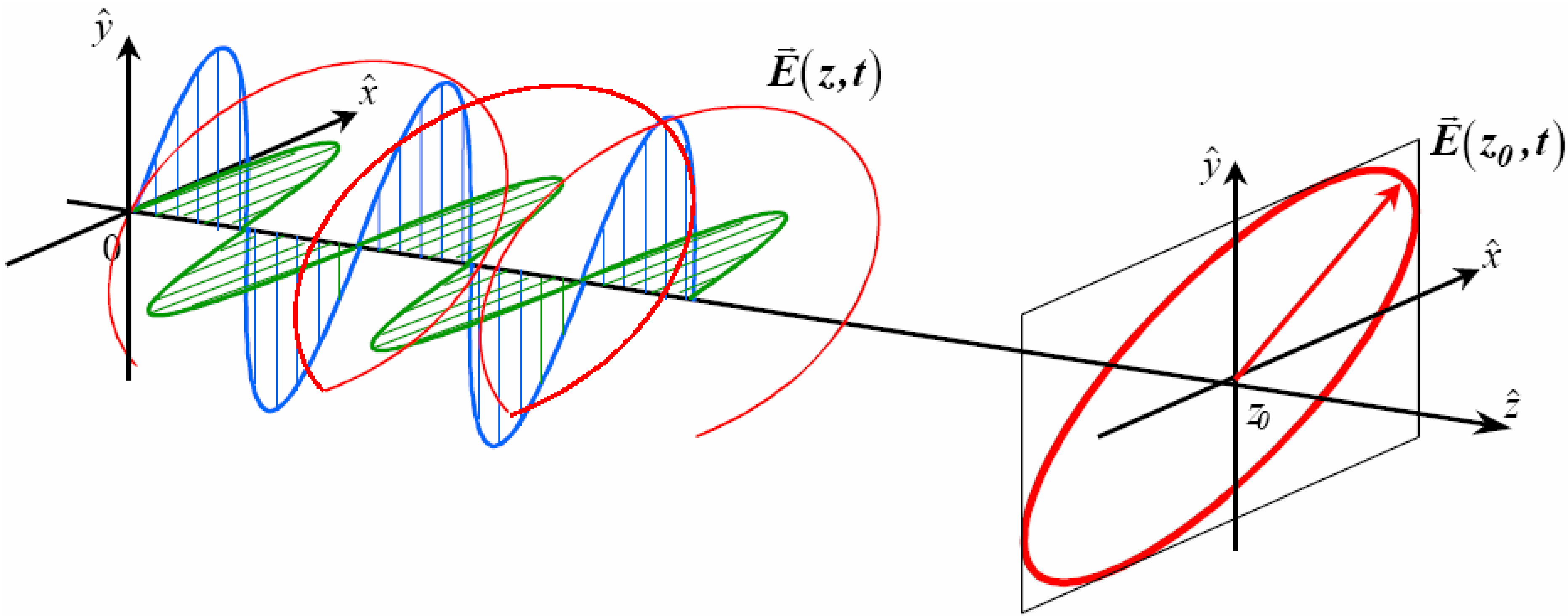
# WAVE POLARIMETRY




**REAL ELECTRIC FIELD VECTOR**

$$\vec{E}(z,t) = \begin{cases} E_x = E_{0x} \cos(\omega t - kz - \delta_x) \\ E_y = E_{0y} \cos(\omega t - kz - \delta_y) \\ E_z = 0 \end{cases}$$

# WAVE POLARIMETRY



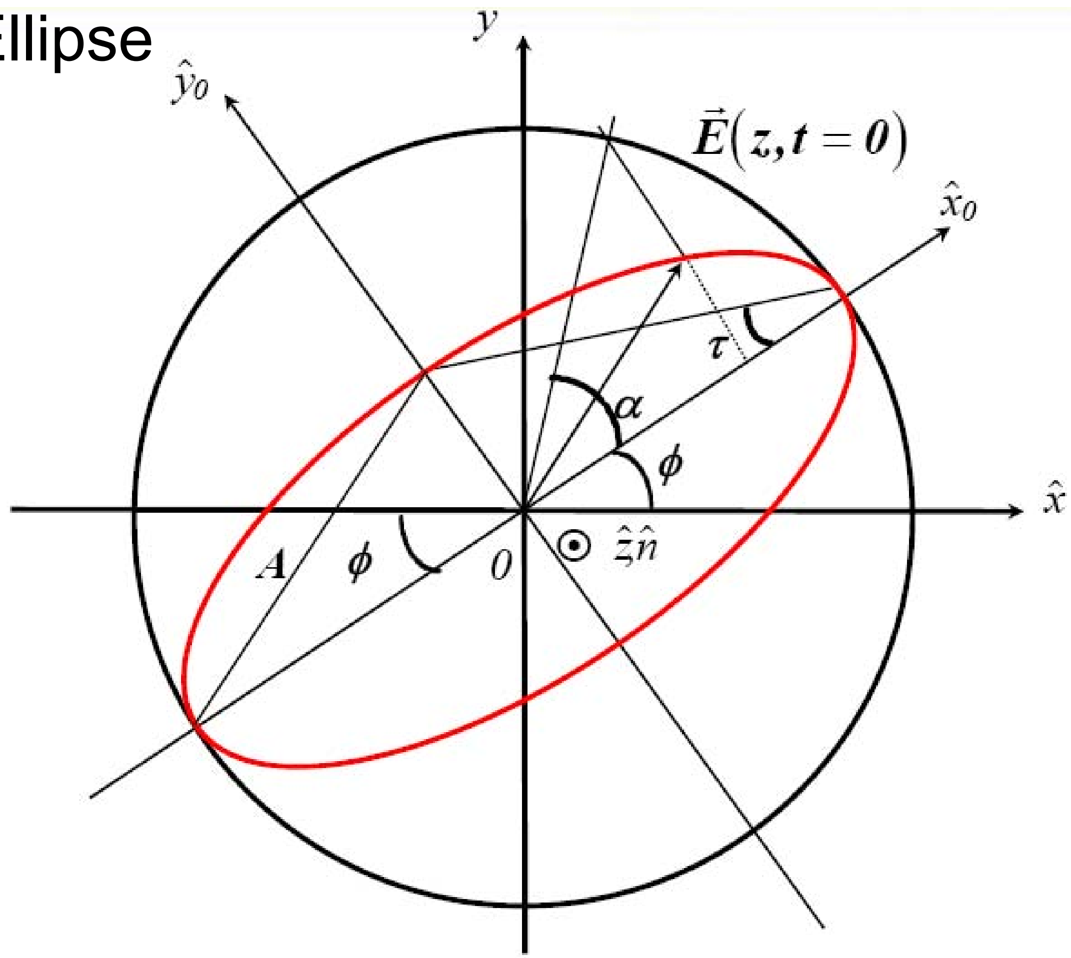

**THE REAL ELECTRIC FIELD VECTOR MOVES IN TIME ALONG AN ELLIPSE**

$$\left(\frac{E_x}{E_{0x}}\right)^2 - 2\frac{E_x E_y}{E_{0x}E_{0y}}\cos(\delta) + \left(\frac{E_y}{E_{0y}}\right)^2 = \sin^2(\delta)$$

**With:** $\delta = \delta_y - \delta_x$

# WAVE POLARIMETRY

## Polarization Ellipse




A : WAVE AMPLITUDE

$\alpha$ : ABSOLUTE PHASE

$\phi$ : ORIENTATION ANGLE $-\dfrac{\pi}{2} \leq \phi \leq \dfrac{\pi}{2}$

$\tau$ : ELLIPTICITY ANGLE $0 \leq \tau \leq \dfrac{\pi}{4}$

# WAVE POLARIMETRY

## Jones Vector

**REAL ELECTRIC FIELD VECTOR**

$$\vec{E}(z,t) = \begin{cases} E_x = E_{0x}\cos(\omega t - kz - \delta_x) \\ E_y = E_{0y}\cos(\omega t - kz - \delta_y) \\ E_z = 0 \end{cases}$$

➡

**PHASOR = JONES VECTOR**

$$\underline{E} = \begin{bmatrix} E_x = E_{ox} e^{j\delta_x} \\ E_y = E_{oy} e^{j\delta_y} \end{bmatrix}$$

**With:** $\vec{E}(z,t) = \Re\left(\underline{E} e^{j(\omega t - kz)}\right)$

**GEOMETRICAL PARAMETERS**

ABSOLUTE PHASE

$$\alpha = \delta_x$$

AMPLITUDE

$$A = \sqrt{E_{0x}^2 + E_{0y}^2}$$

ORIENTATION ANGLE

$$\tan 2\phi = 2\frac{E_{0x}E_{0y}}{E_{0x}^2 - E_{0y}^2}\cos\delta$$

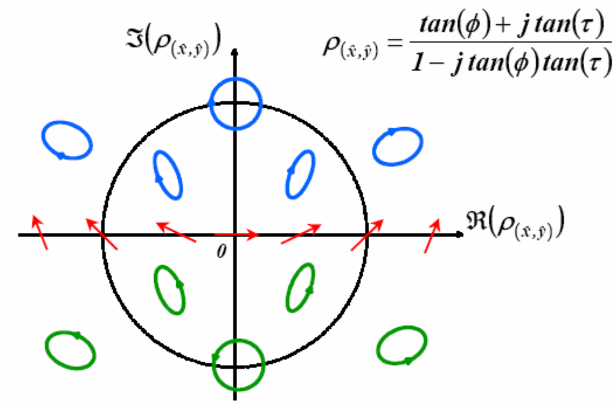
ELLIPTICITY ANGLE

$$\sin 2\tau = 2\frac{E_{0x}E_{0y}}{E_{0x}^2 + E_{0y}^2}\sin\delta$$

POLARISATION HANDENESS: $Sign(\tau)$

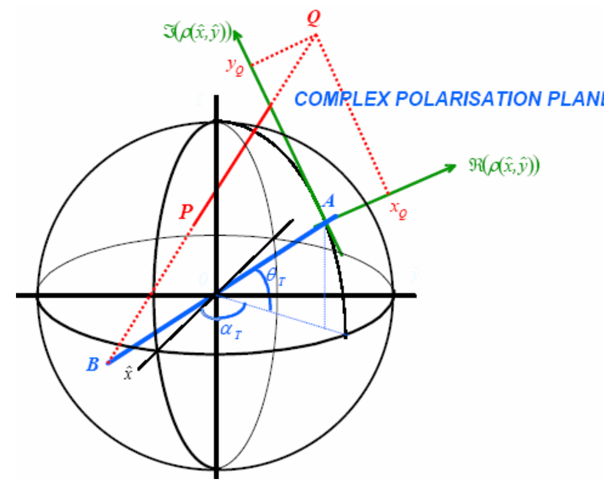
# WAVE POLARIMETRY

## Polarimetric Descriptors




→ Complex Polarization Ratio

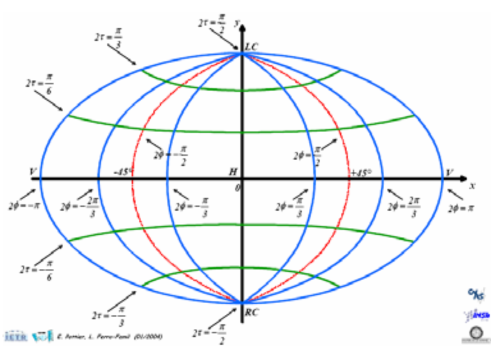
→ Complex Polarization Plane




→ Stokes Vector

→ Poincaré Sphere

$$\underline{g}_E = \begin{bmatrix} g_0 \\ g_1 \\ g_2 \\ g_3 \end{bmatrix} = \begin{bmatrix} |E_x|^2 + |E_y|^2 \\ |E_x|^2 - |E_y|^2 \\ 2\Re(E_x E_y^*) \\ -2\Im(E_x E_y^*) \end{bmatrix}$$




→Deschamps parameters

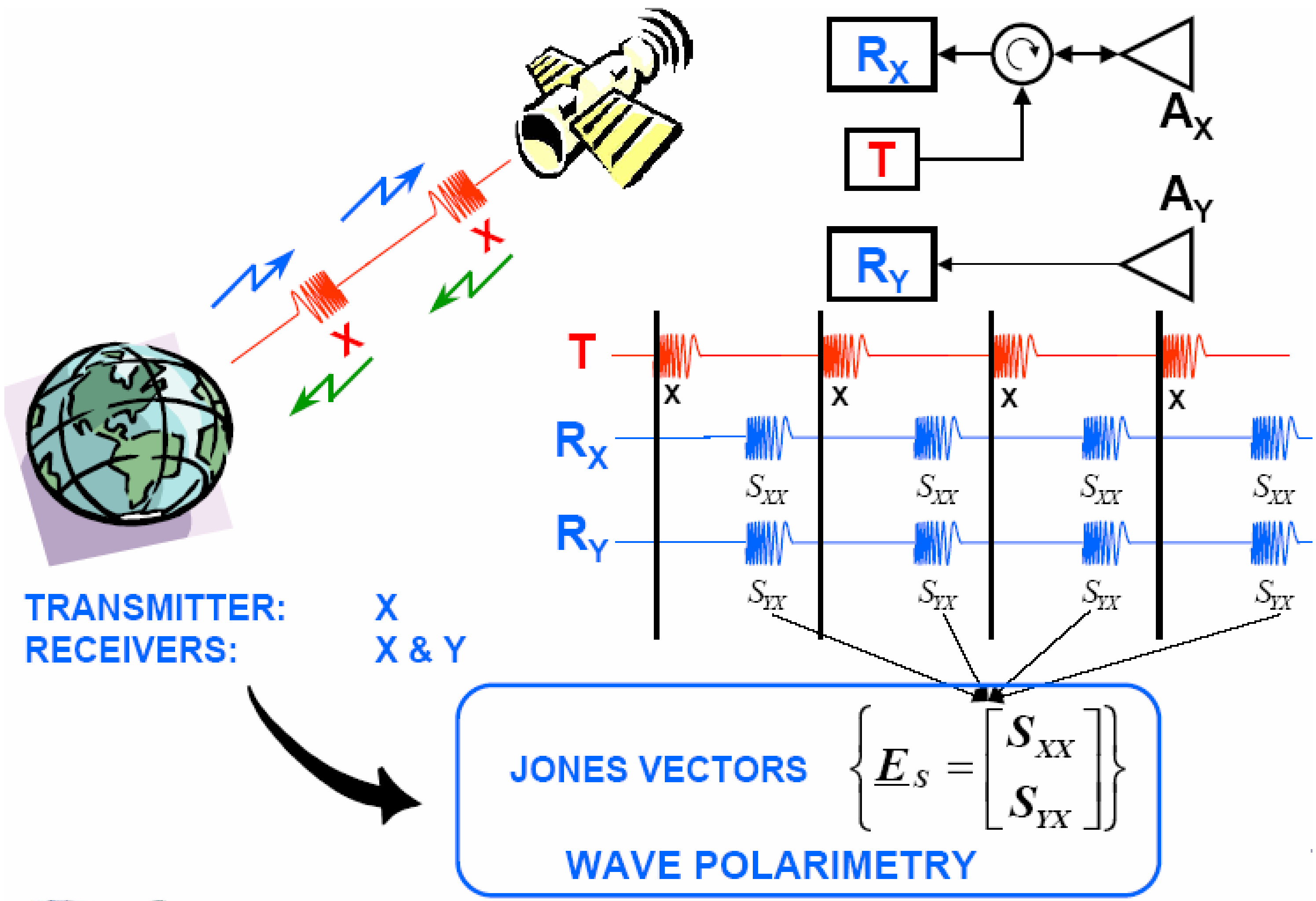
→ Poincaré Planisphere

→ Covariance Matrix

# SCATTERING POLARIMETRY

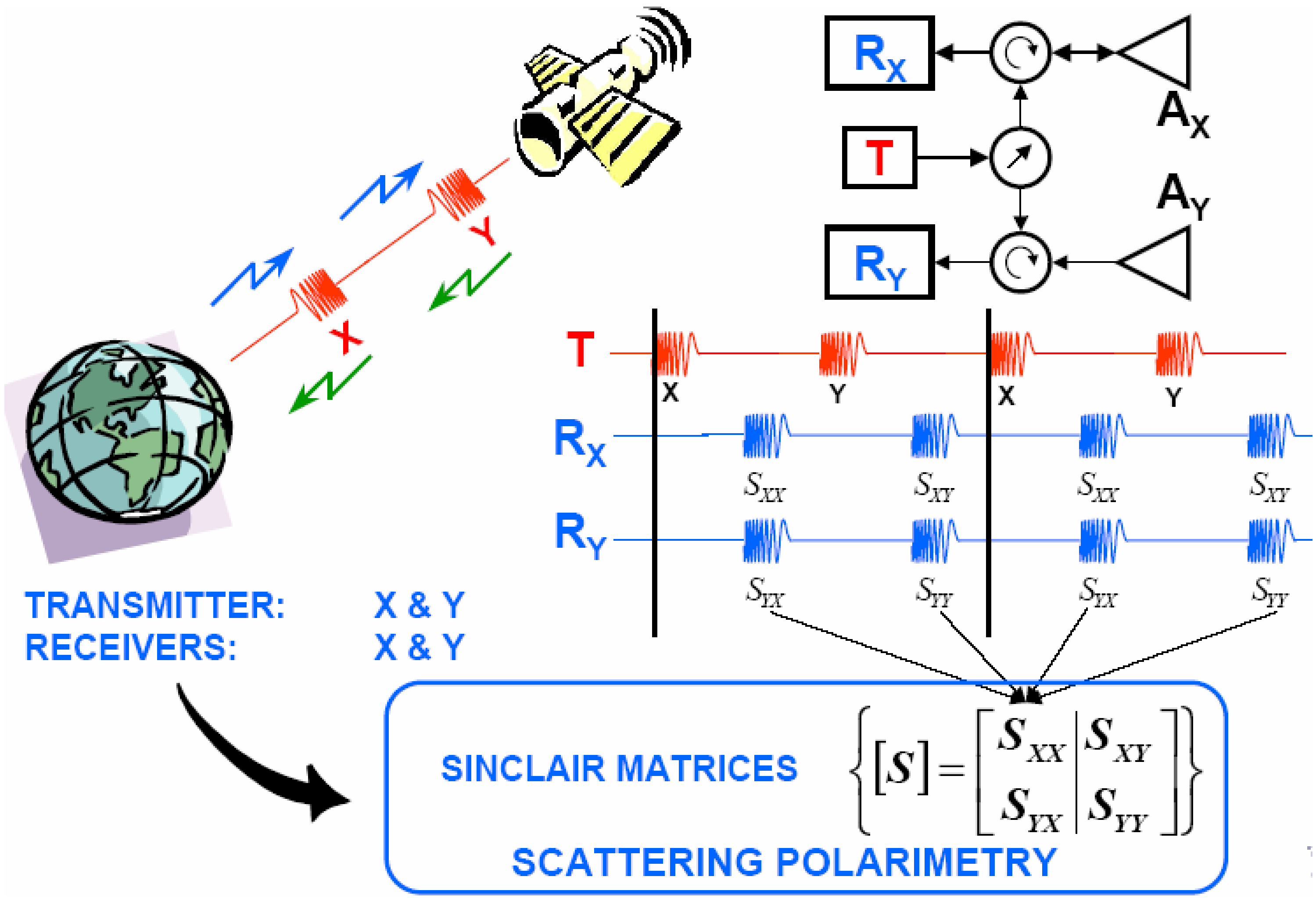
# SCATTERING POLARIMETRY

## Single polarization



# SCATTERING POLARIMETRY

## Scattering matrix



# SCATTERING POLARIMETRY

## Scattering matrix

### SCATTERING MATRIX or JONES MATRIX

$$\begin{bmatrix} E_X^s \\ E_Y^s \end{bmatrix} = \frac{e^{jkr}}{r} \begin{bmatrix} S_{XX} & S_{XY} \\ S_{YX} & S_{YY} \end{bmatrix} \begin{bmatrix} E_X^i \\ E_Y^i \end{bmatrix}$$

DEFINED IN THE LOCAL COORDINATES SYSTEM

$[S]$ IS INDEPENDENT OF THE POLARISATION STATE OF THE INCIDENCE WAVE

$[S]$ IS DEPENDENT ON THE FREQUENCY AND THE GEOMETRICAL AND ELECTRICAL PROPERTIES OF THE SCATTERER

TOTAL SCATTERED POWER

$$Span([S]) = Trace([S][S]^{T*}) = |S_{XX}|^2 + |S_{XY}|^2 + |S_{YX}|^2 + |S_{YY}|^2$$

# SCATTERING POLARIMETRY

## Backscattering matrix

**BACKSCATTERING MATRIX or SINCLAIR MATRIX**

⬇

**In the case of Backscattering from Reciprocal Scatterers:**

**RECIPROCITY THEOREM** $S_{XY}^{BSA} = S_{YX}^{BSA} \Leftrightarrow S_{XY}^{FSA} = -S_{YX}^{FSA}$

⬇

$$\begin{bmatrix} E_X^s \\ E_Y^s \end{bmatrix} = \frac{e^{jkr}}{r} \begin{bmatrix} S_{XX} & S_{XY} \\ S_{XY} & S_{YY} \end{bmatrix} \begin{bmatrix} E_X^i \\ E_Y^i \end{bmatrix}$$

**(BSA CONVENTION)**

**TOTAL SCATTERED POWER**

$$Span([S]) = Trace\left([S][S]^{T*}\right) = |S_{XX}|^2 + 2|S_{XY}|^2 + |S_{YY}|^2$$

# SCATTERING POLARIMETRY

## Polarimetric dimension

$$[S] = \frac{e^{jkr}}{r}\begin{bmatrix} S_{XX} & S_{XY} \\ S_{XY} & S_{YY} \end{bmatrix} = \frac{e^{jkr}}{r}\begin{bmatrix} |S_{XX}|e^{j\varphi_{XX}} & |S_{XY}|e^{j\varphi_{XY}} \\ |S_{XY}|e^{j\varphi_{XY}} & |S_{YY}|e^{j\varphi_{YY}} \end{bmatrix}$$

**ABSOLUTE BACKSCATTERING MATRIX**

$$[S] = \frac{e^{jkr}e^{j\phi_{XX}}}{r}\begin{bmatrix} |S_{XX}| & |S_{XY}|e^{j(\varphi_{XY}-\varphi_{XX})} \\ |S_{XY}|e^{j(\varphi_{XY}-\varphi_{XX})} & |S_{YY}|e^{j(\varphi_{YY}-\varphi_{XX})} \end{bmatrix}$$

**Absolute Phase Factor**

**RELATIVE BACKSCATTERING MATRIX**

**Five Parameters: 3 Amplitudes and 2 Phases**

**SCATTERER POLARIMETRIC DIMENSION = 5**

# SCATTERING POLARIMETRY

## Elliptical Basis Transformation

$$\left[S_{(B,B_\perp)}\right] = \left[U_{(A,A_\perp)\mapsto(B,B_\perp)}\right]^T \left[S_{(A,A_\perp)}\right]\left[U_{(A,A_\perp)\mapsto(B,B_\perp)}\right]$$

**CON-SIMILARITY TRANSFORMATION**

$$\left[U_{(A,A_\perp)\mapsto(B,B_\perp)}\right]$$

**SU(2) SPECIAL UNITARY ELLIPTICAL BASIS TRANSFORMATION MATRIX**

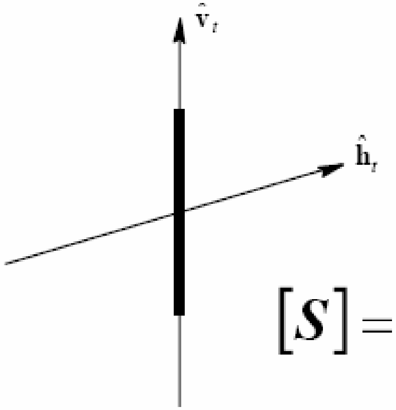
$$\left[U_{(A,A_\perp)\mapsto(B,B_\perp)}\right] = \begin{bmatrix} \cos(\phi) & -\sin(\phi) \\ \sin(\phi) & \cos(\phi) \end{bmatrix} \begin{bmatrix} \cos(\tau) & j\sin(\tau) \\ j\sin(\tau) & \cos(\tau) \end{bmatrix} \begin{bmatrix} e^{-j\alpha} & 0 \\ 0 & e^{j\alpha} \end{bmatrix}$$

$$[U_2(\phi)] \qquad [U_2(\tau)] \qquad [U_2(\alpha)]$$

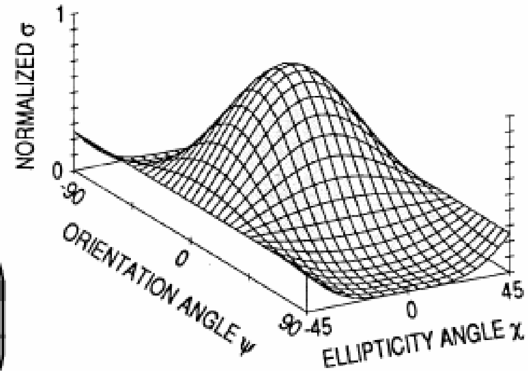
# SCATTERING POLARIMETRY

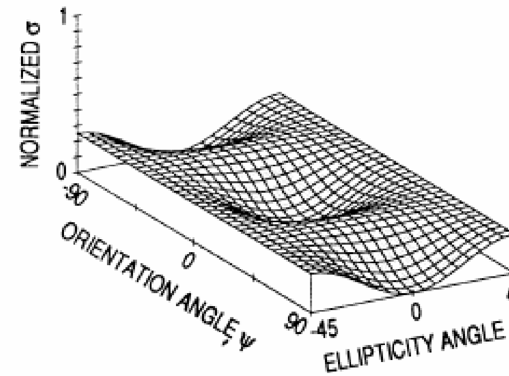
## Polarimetric signature

### SHORT THIN CYLINDER

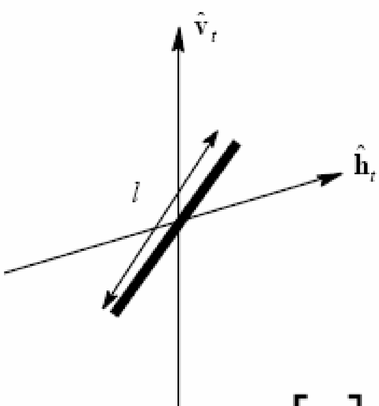



$$[S] = c \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix}$$

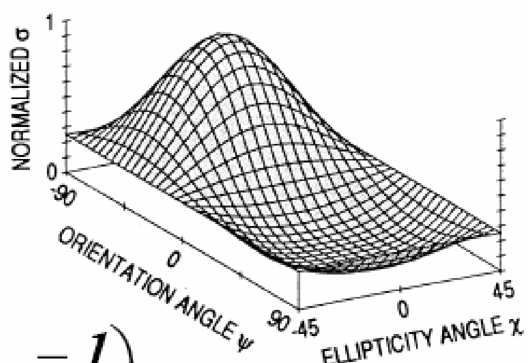


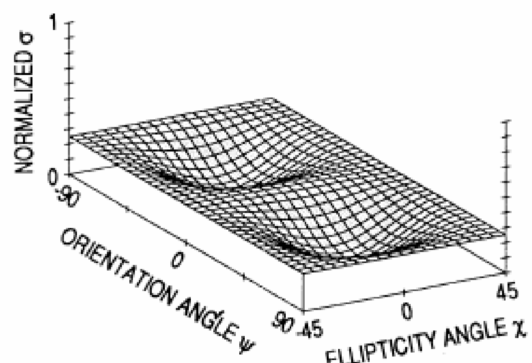




### ORIENTED SHORT THIN CYLINDER




$$[S] = c \begin{pmatrix} 1 & -1 \\ -1 & 1 \end{pmatrix}$$

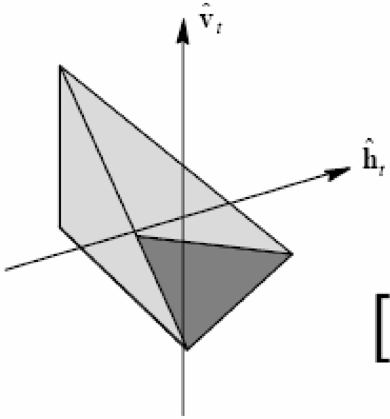


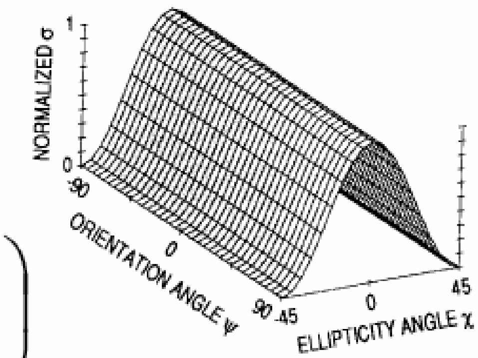
# SCATTERING POLARIMETRY

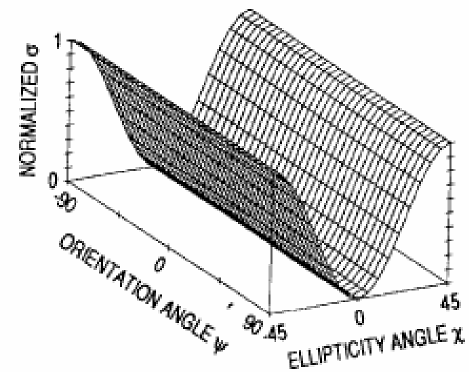
## Polarimetric signature

### TRIHEDRAL CORNER REFLECTOR

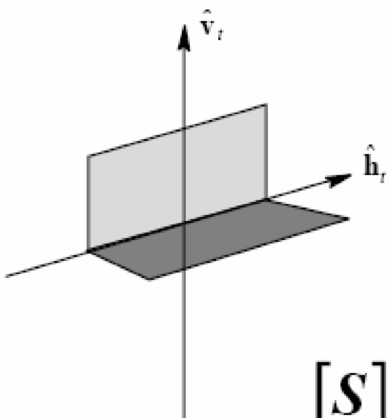



$$[S] = c \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

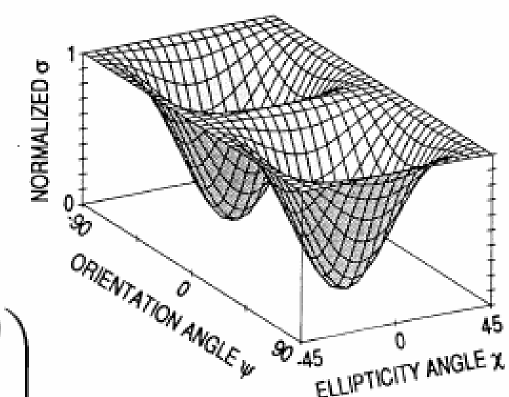


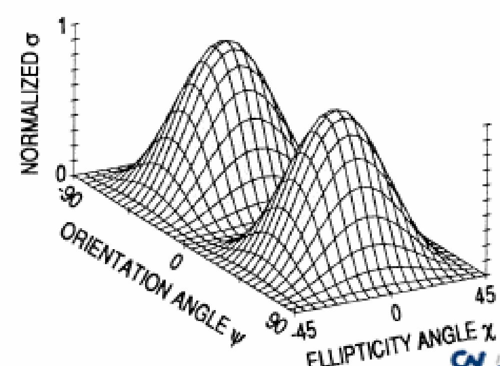




### DIHEDRAL CORNER REFLECTOR



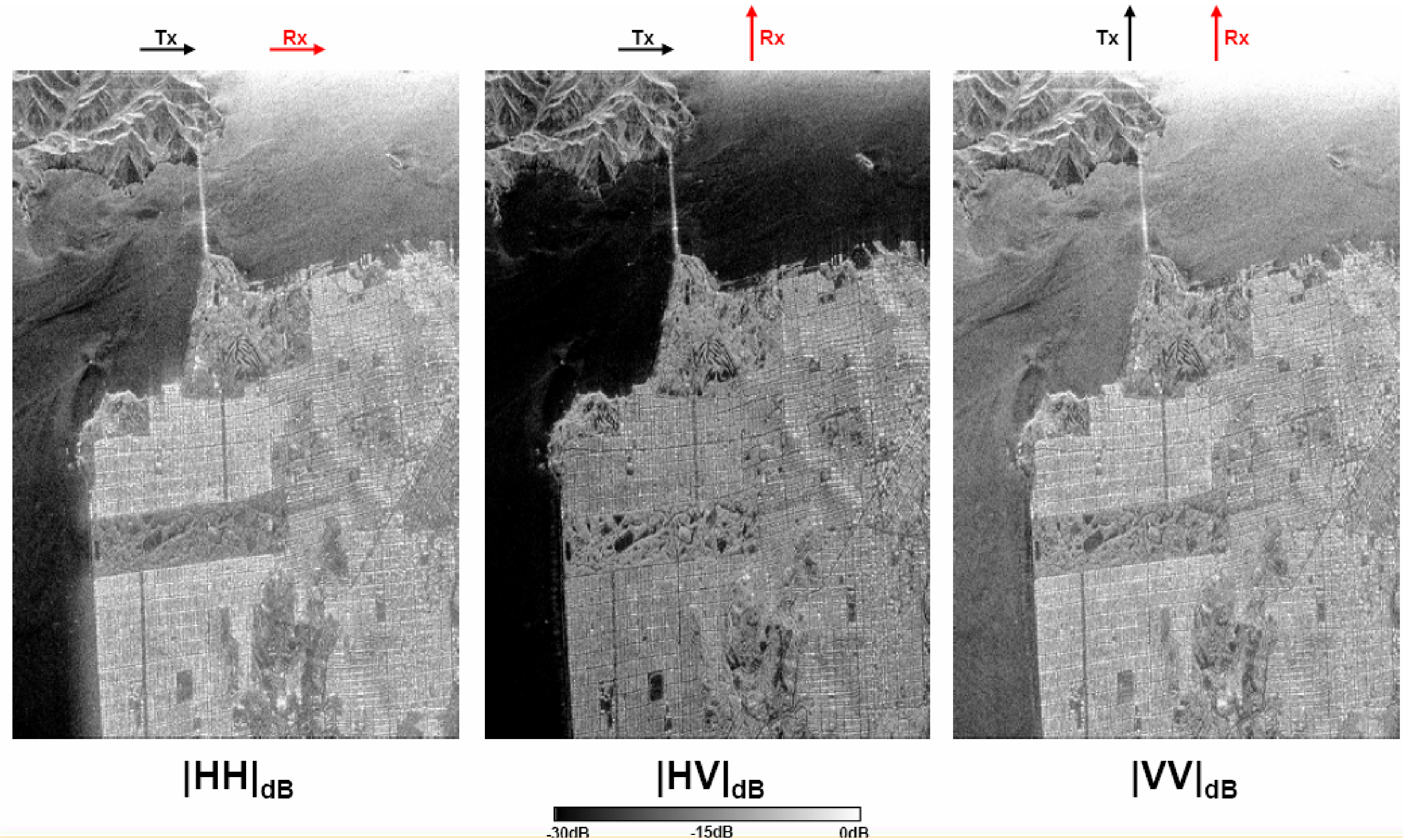

$$[S] = c \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$



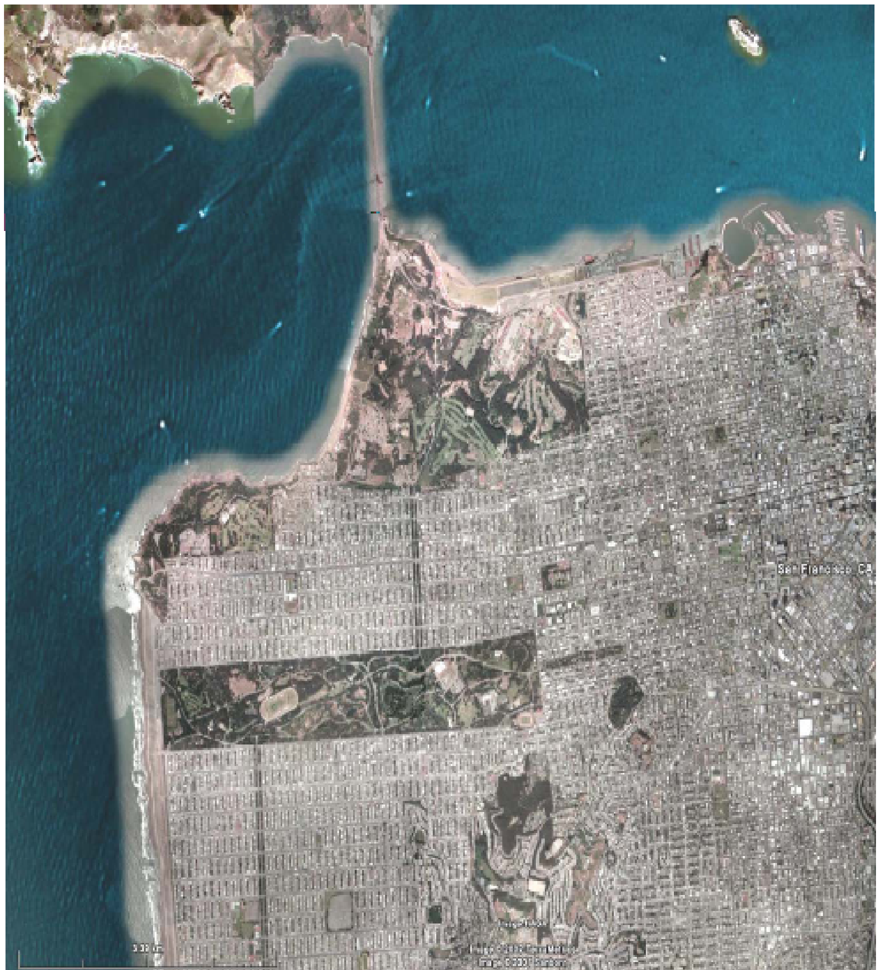
# SCATTERING POLARIMETRY

## San Francisco Bay (AIRSAR) → Polarimetric Information



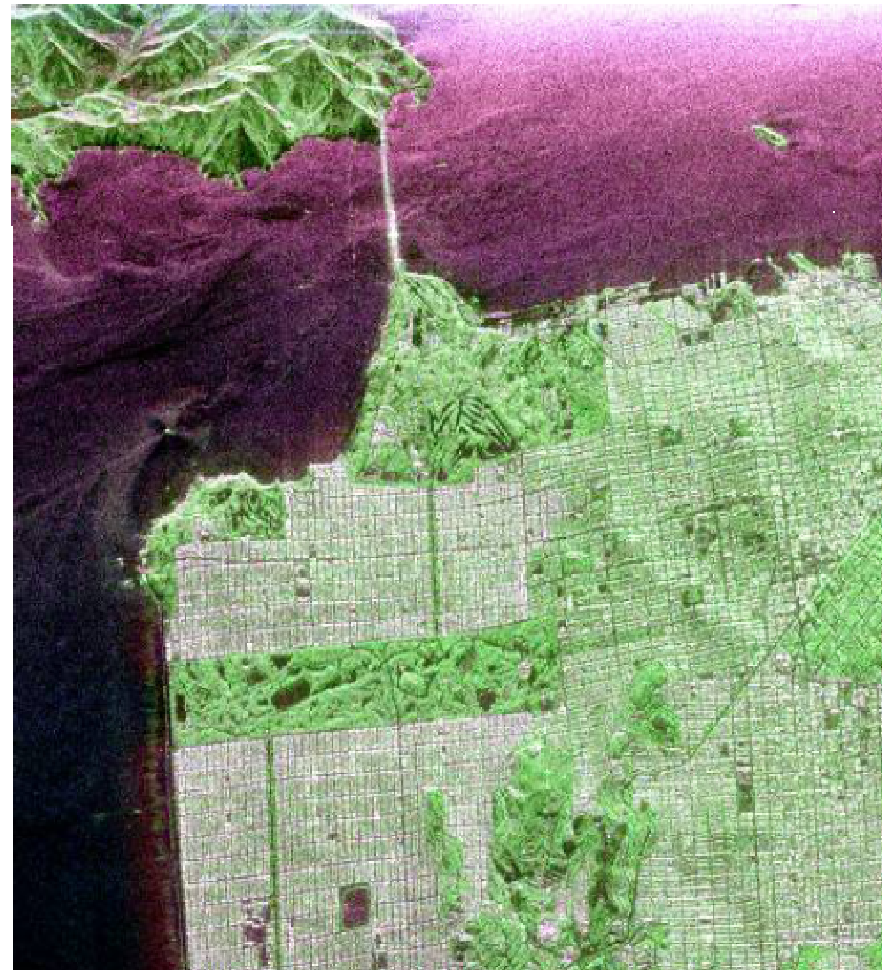
# SCATTERING POLARIMETRY

## San Francisco Bay (AIRSAR) → Polarimetric Information




© Google Earth

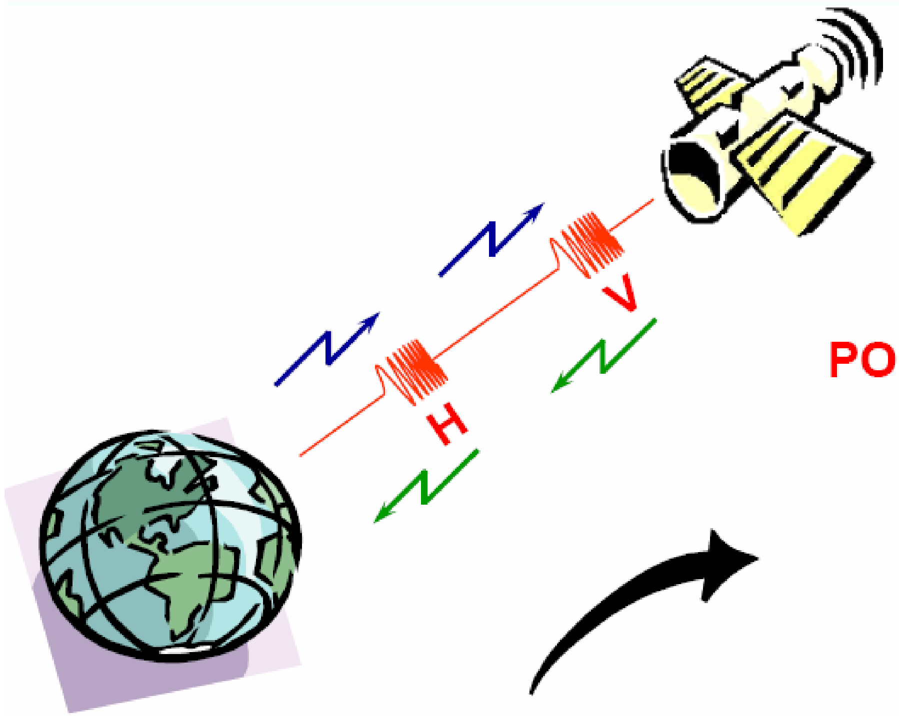
**Sinclair Color Coding**



|HH| |HV| |VV|

# SCATTERING POLARIMETRY

## Polarimetric Descriptors




**POLARIMETRIC DESCRIPTORS**

**[S]** **SINCLAIR Matrix**

$$[S] = \begin{bmatrix} S_{HH} & S_{HV} \\ S_{VH} & S_{VV} \end{bmatrix}$$

**TRANSMITTER:** **H & V**
**RECEIVERS:** **H & V**

**$\underline{k}$** **Target Vector**

**[T]** **3x3 COHERENCY Matrix**

# SCATTERING POLARIMETRY

## Target Vector

**VECTORIZATION OF [S]**

$$[S]=\begin{bmatrix} S_{HH} & S_{HV} \\ S_{HV} & S_{VV} \end{bmatrix} \Rightarrow \underline{k}=V([S])=\frac{1}{2}Trace([S][\psi])$$

**SET OF 2x2 COMPLEX MATRICES**
**FROM THE PAULI MATRICES GROUP**

$$[\psi_P]=\left\{\sqrt{2}\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix},\sqrt{2}\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix},\sqrt{2}\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}\right\}$$

**TARGET VECTOR**

$$\underline{k}=\frac{1}{\sqrt{2}}\begin{bmatrix} S_{HH}+S_{VV} & S_{HH}-S_{VV} & 2S_{HV} \end{bmatrix}^T$$

**FROBENIUS NORM = SPAN [S]**

$$\|\underline{k}\|^2=\underline{k}^{T*}\underline{k}=span([S])=Trace\left([S][S]^*\right)=|S_{HH}|^2+2|S_{HV}|^2+|S_{VV}|^2$$

# SCATTERING POLARIMETRY

## Coherency Matrix

**TARGET VECTOR $\underline{k}$**

$$\underline{k} = \frac{1}{\sqrt{2}}\left[S_{HH} + S_{VV} \quad S_{HH} - S_{VV} \quad 2S_{HV}\right]^T$$

**COHERENCY MATRIX [*T*]**

$$[T] = \underline{k} \cdot \underline{k}^{*T} = \begin{bmatrix} 2A_0 & C - jD & H + jG \\ C + jD & B_0 + B & E + jF \\ H - jG & E - jF & B_0 - B \end{bmatrix}$$

**HERMITIAN MATRIX - RANK 1**

**A0, B0+B, B0-B : HUYNEN TARGET GENERATORS**

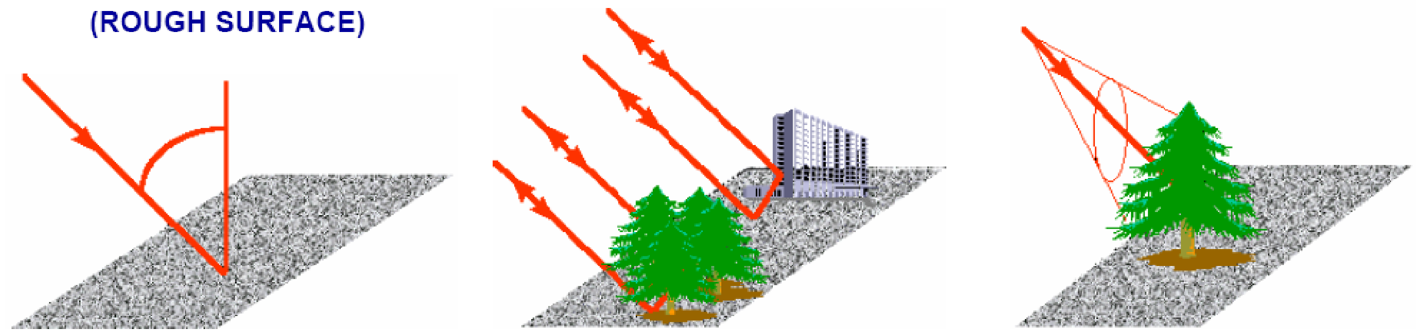
$[T]$ is closer related to Physical and Geometrical Properties of the Scattering Process, and thus allows a better and direct physical interpretation

# SCATTERING POLARIMETRY

## Target Generators

**PHYSICAL INTERPRETATION**

**SINGLE BOUNCE SCATTERING (ROUGH SURFACE)** | **DOUBLE BOUNCE SCATTERING** | **VOLUME SCATTERING**



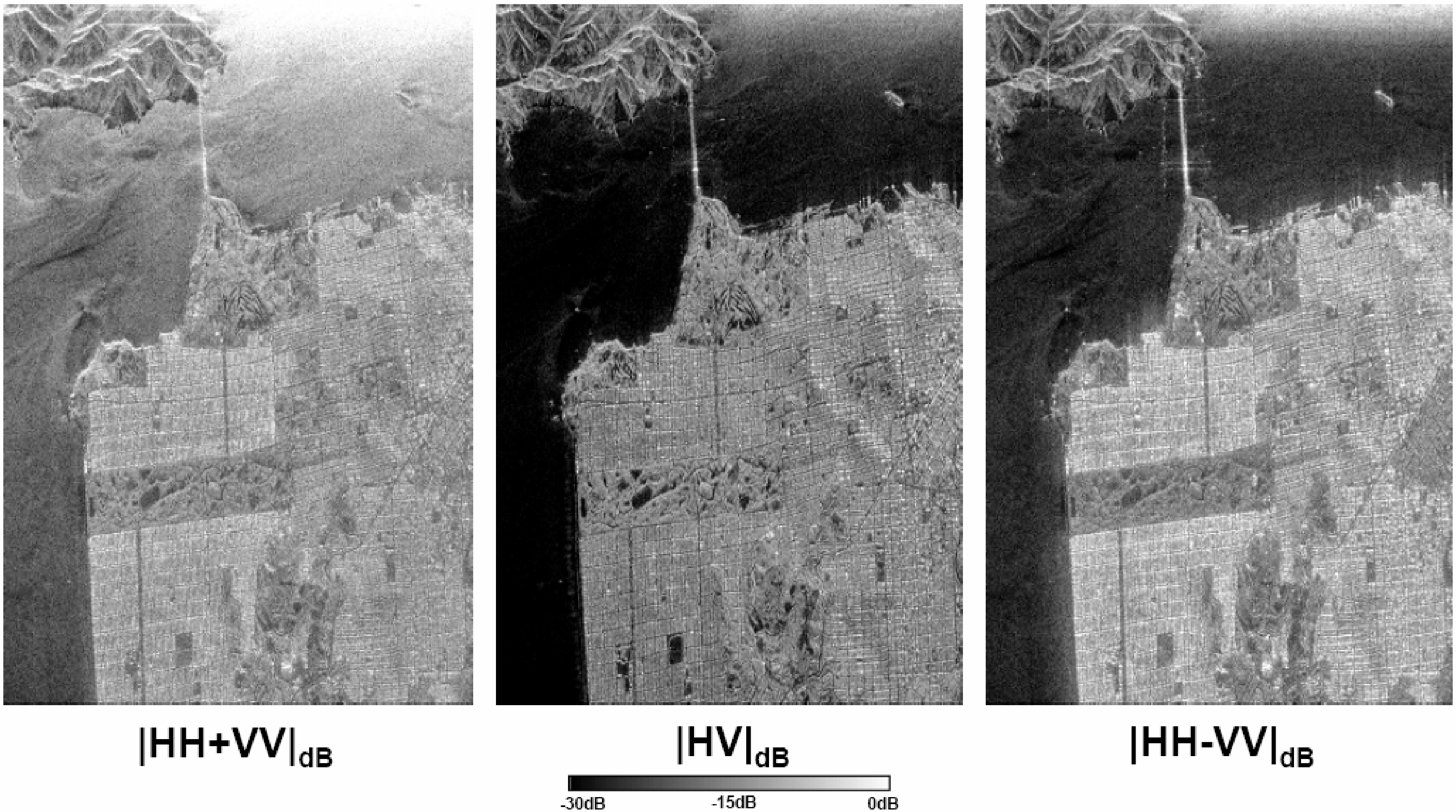
$$T_{11} = 2A_0 = \left|S_{HH} + S_{VV}\right|^2$$

$$T_{33} = B_0 - B = 2\left|S_{HV}\right|^2$$

$$T_{22} = B_0 + B = \left|S_{HH} - S_{VV}\right|^2$$

# SCATTERING POLARIMETRY

## San Francisco Bay (PAULI Basis)



# SCATTERING POLARIMETRY

## San Francisco Bay (Pauli Composition)

© Google Earth

|HH+VV| $T_{11}=2A_0$

|HV| $T_{33}=B_0-B$

|HH-VV| $T_{22}=B_0+B$

# SCATTERING POLARIMETRY

## Elliptical Basis Change on Coherence Matrix

**SINCLAIR MATRIX**

$$\left[S_{(B,B_\perp)}\right] = \left[U_{(A,A_\perp)\mapsto(B,B_\perp)}\right]^T \left[S_{(A,A_\perp)}\right]\left[U_{(A,A_\perp)\mapsto(B,B_\perp)}\right]$$

**CON-SIMILARITY TRANSFORMATION**

$\left[U_{2(A,A_\perp)\mapsto(B,B_\perp)}\right]$ **U(2) SPECIAL UNITARY ELLIPTICAL BASIS TRANSFORMATION MATRIX**

**COHERENCY MATRIX**

$$\left[T_{(B,B_\perp)}\right] = \left[U_{3(A,A_\perp)\mapsto(B,B_\perp)}\right]\left[T_{(A,A_\perp)}\right]\left[U_{3(A,A_\perp)\mapsto(B,B_\perp)}\right]^{-1}$$

**SIMILARITY TRANSFORMATION**

$\left[U_{3(A,A_\perp)\mapsto(B,B_\perp)}\right]$ **U(3) SPECIAL UNITARY ELLIPTICAL BASIS TRANSFORMATION MATRIX**

# SCATTERING POLARIMETRY

## Elliptical Basis Change on Coherence Matrix

**SPECIAL UNITARY SU(2) GROUP**

$$[U] = \begin{bmatrix} cos(\phi) & -sin(\phi) \\ sin(\phi) & cos(\phi) \end{bmatrix} \begin{bmatrix} cos(\tau) & j\,sin(\tau) \\ j\,sin(\tau) & cos(\tau) \end{bmatrix} \begin{bmatrix} e^{-j\alpha} & 0 \\ 0 & e^{j\alpha} \end{bmatrix}$$

$$[U_2(\phi)] \qquad [U_2(\tau)] \qquad [U_2(\alpha)]$$

**SPECIAL UNITARY SU(3) GROUP**

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & cos(2\phi) & sin(2\phi) \\ 0 & -sin(2\phi) & cos(2\phi) \end{bmatrix} \begin{bmatrix} cos(2\tau) & 0 & j\,sin(2\tau) \\ 0 & 1 & 0 \\ j\,sin(2\tau) & 0 & cos(2\tau) \end{bmatrix} \begin{bmatrix} cos(2\alpha) & -j\,sin(2\alpha) & 0 \\ -j\,sin(2\alpha) & cos(2\alpha) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

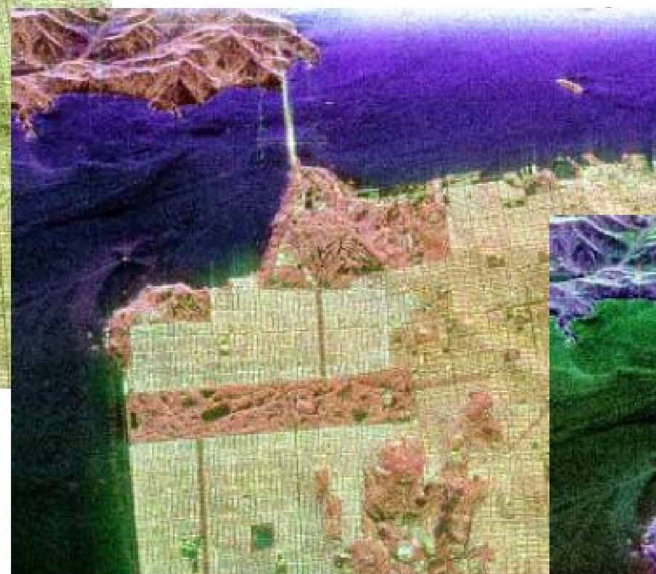
$$[U_3(2\phi)] \qquad [U_3(2\tau)] \qquad [U_3(2\alpha)]$$

$(\phi, \tau, \alpha)$ **POLARIZATION ELLIPSE PARAMETERS**

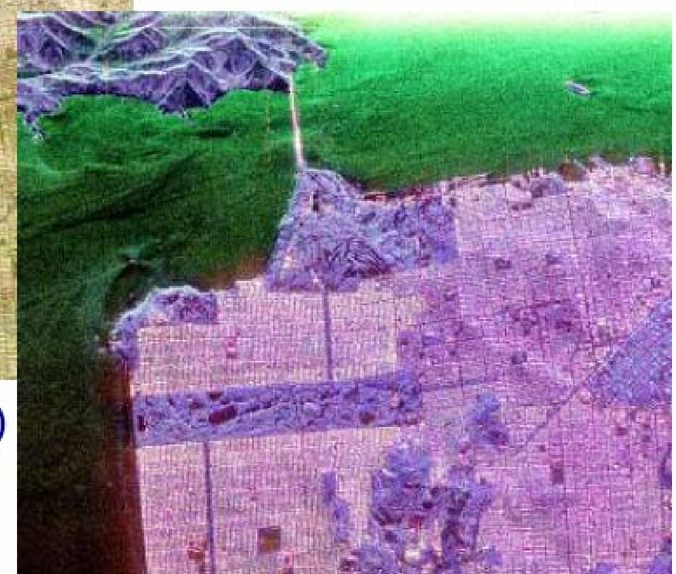
# SCATTERING POLARIMETRY

## Elliptical Basis Transformation

Pauli Color Coding (H,V)



Pauli Color Coding (+45,-45)



Pauli Color Coding (L,R)

Ernst LÜNEBURG
(PIERS95 - Pasadena)

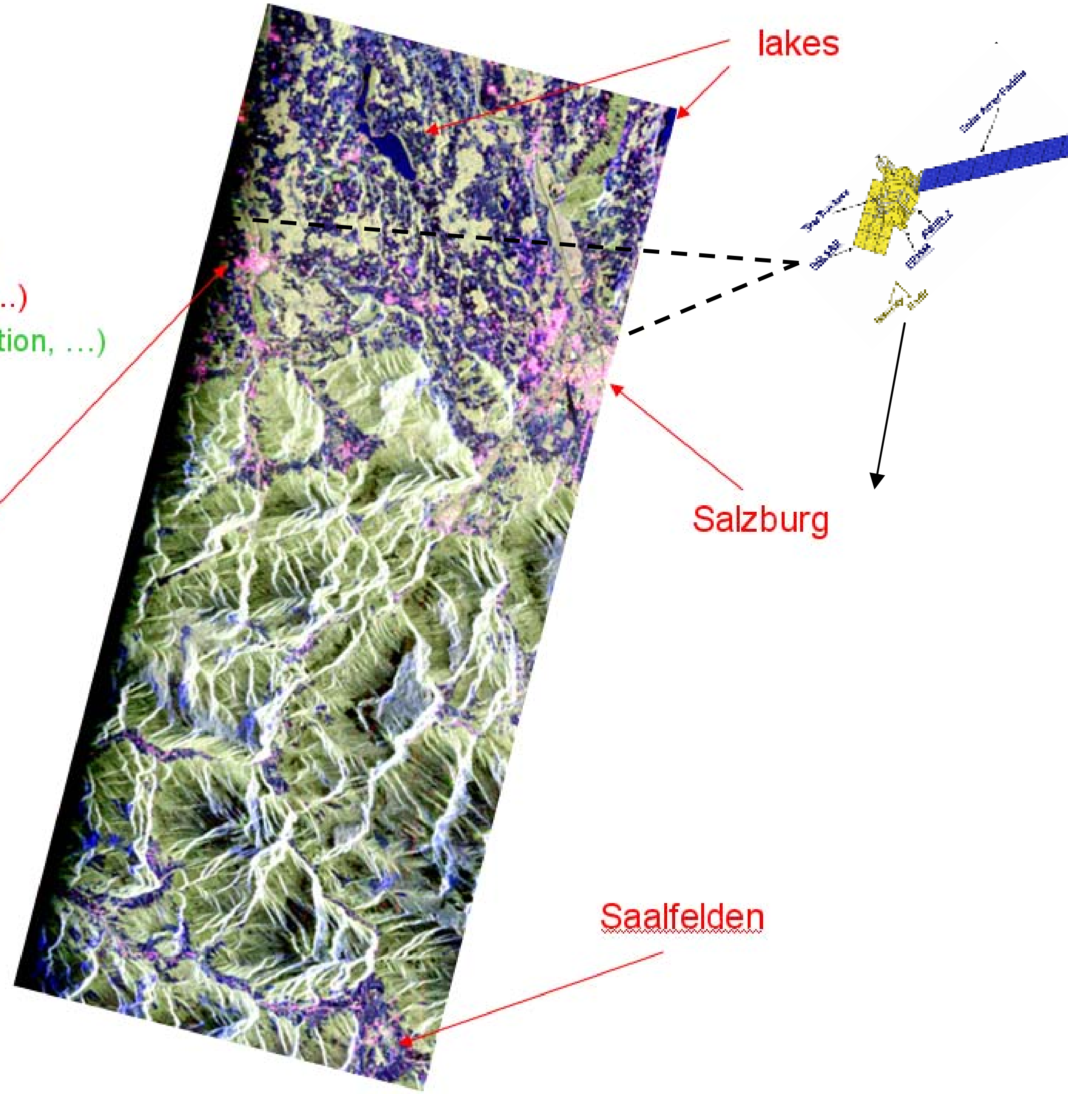
# SCATTERING POLARIMETRY

## ALOS PALSAR Sept 2007 - Traunstein Forest (Germany)

B: HH+VV → single bounce (lakes, …)

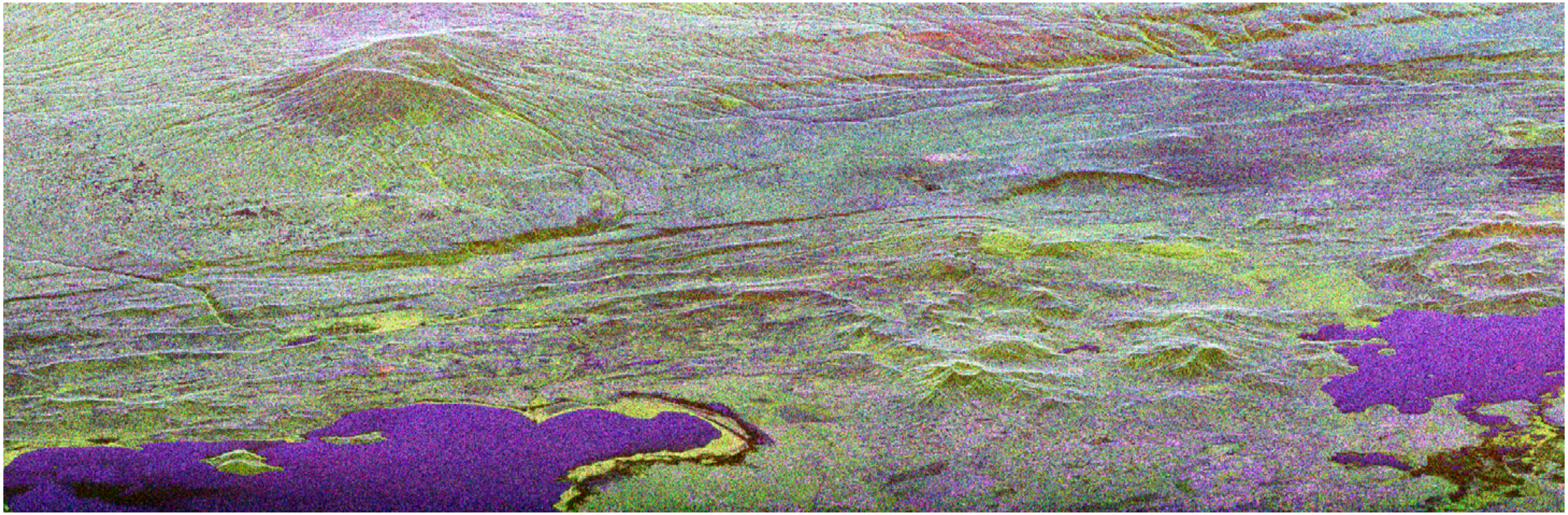
R: HH-VV → double bounce (building, …)

G: 2HV → volume scattering (vegetation, …)



# SCATTERING POLARIMETRY

## ALOS PALSAR Jun 2007 - Etiopia

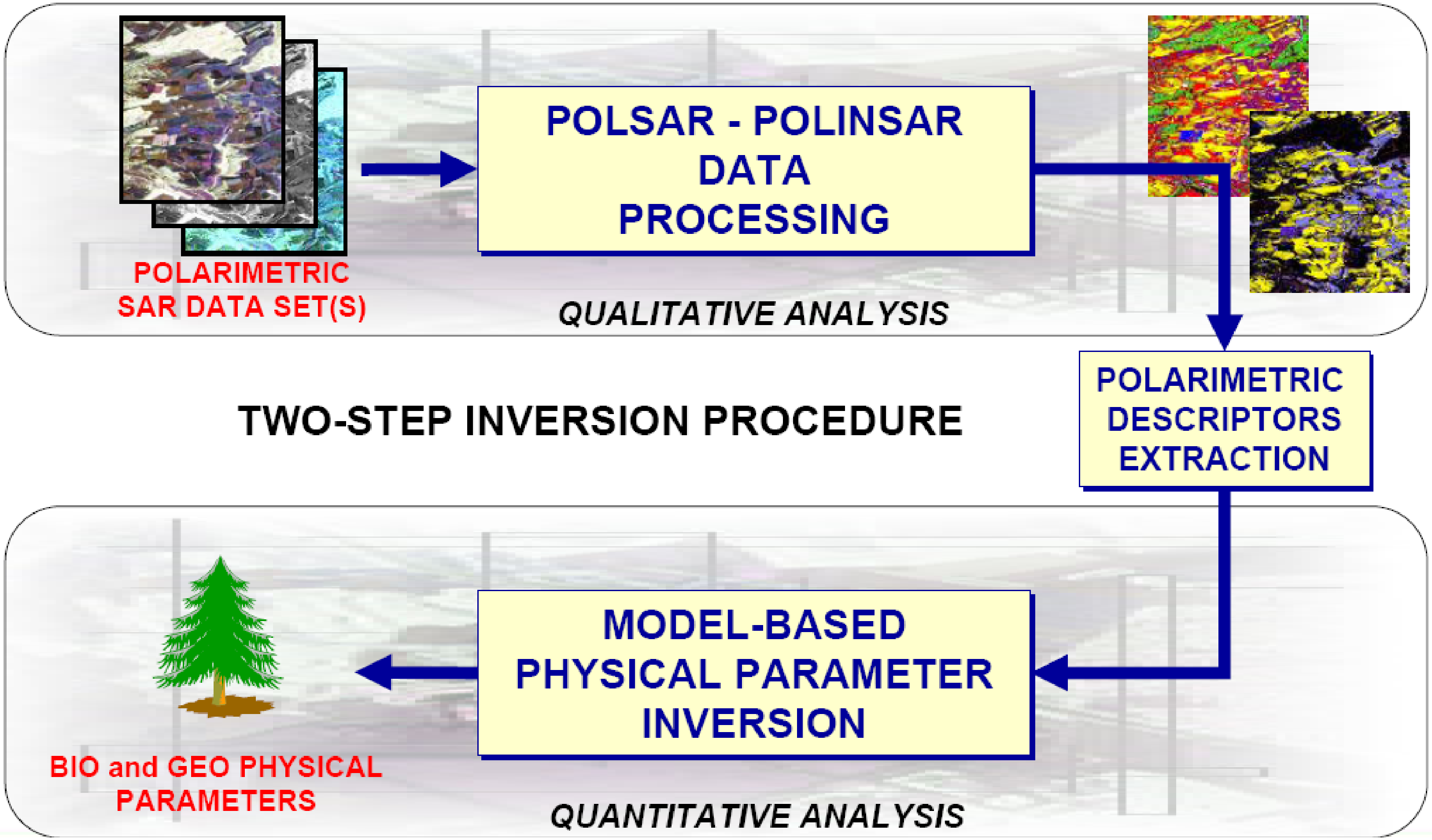


B: HH+VV → single bounce (lakes, …)
R: HH-VV → double bounce (building, …)
G: 2HV → volume scattering (vegetation, …)

# POLARIMETRIC REMOTE SENSING

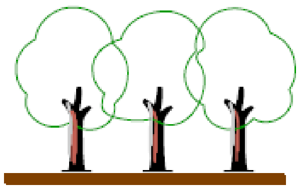
# POLARIMETRIC REMOTE SENSING

## Quantitative analysis



# POLARIMETRIC REMOTE SENSING

## Target Decomposition Theorems



**PURE TARGET**

**COHERENCY MATRIX $[T]$**

**9 REAL DEPENDANT HUYNEN PARAMETERS (A0,B0,B,C,D,E,F,G,H)**

**POLARIMETRIC DISTRIBUTED TARGET « *DIMENSION* » = 5**

**9 - 5 = 4 TARGET EQUATIONS**

$$2A_0(B_0+B) = C^2+D^2$$

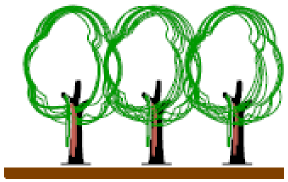
$$2A_0(B_0-B) = G^2+H^2$$

$$2A_0E = CH-DG$$

$$2A_0F = CG+DH$$

# POLARIMETRIC REMOTE SENSING

## Target Decomposition Theorems



**DISTRIBUTED TARGET**

**POLARIMETRIC DISTRIBUTED TARGET « *DIMENSION* » = 9**

**COHERENCY MATRIX** $<[T]>$

**9 REAL INDEPENDANT HUYNEN PARAMETERS**

**(<A0>,<B0>,<B>,<C>,<D>,<E>,<F>,<G>,<H>)**

### 9 TARGET INEQUATIONS

$$2\langle A_0\rangle\left(\langle B_0\rangle+\langle B\rangle\right)\geq\langle C\rangle^2+\langle D\rangle^2$$

$$2\langle A_0\rangle\left(\langle B_0\rangle-\langle B\rangle\right)\geq\langle G\rangle^2+\langle H\rangle^2$$

$$2\langle A_0\rangle\langle E\rangle\geq\langle C\rangle\langle H\rangle-\langle D\rangle\langle G\rangle$$

$$2\langle A_0\rangle\langle F\rangle\geq\langle C\rangle\langle G\rangle+\langle D\rangle\langle H\rangle$$

$$\langle B_0\rangle^2\geq\langle B\rangle^2+\langle E\rangle^2+\langle F\rangle^2$$

$$\langle H\rangle\left(\langle B_0\rangle+\langle B\rangle\right)\geq\langle C\rangle\langle E\rangle+\langle D\rangle\langle F\rangle$$

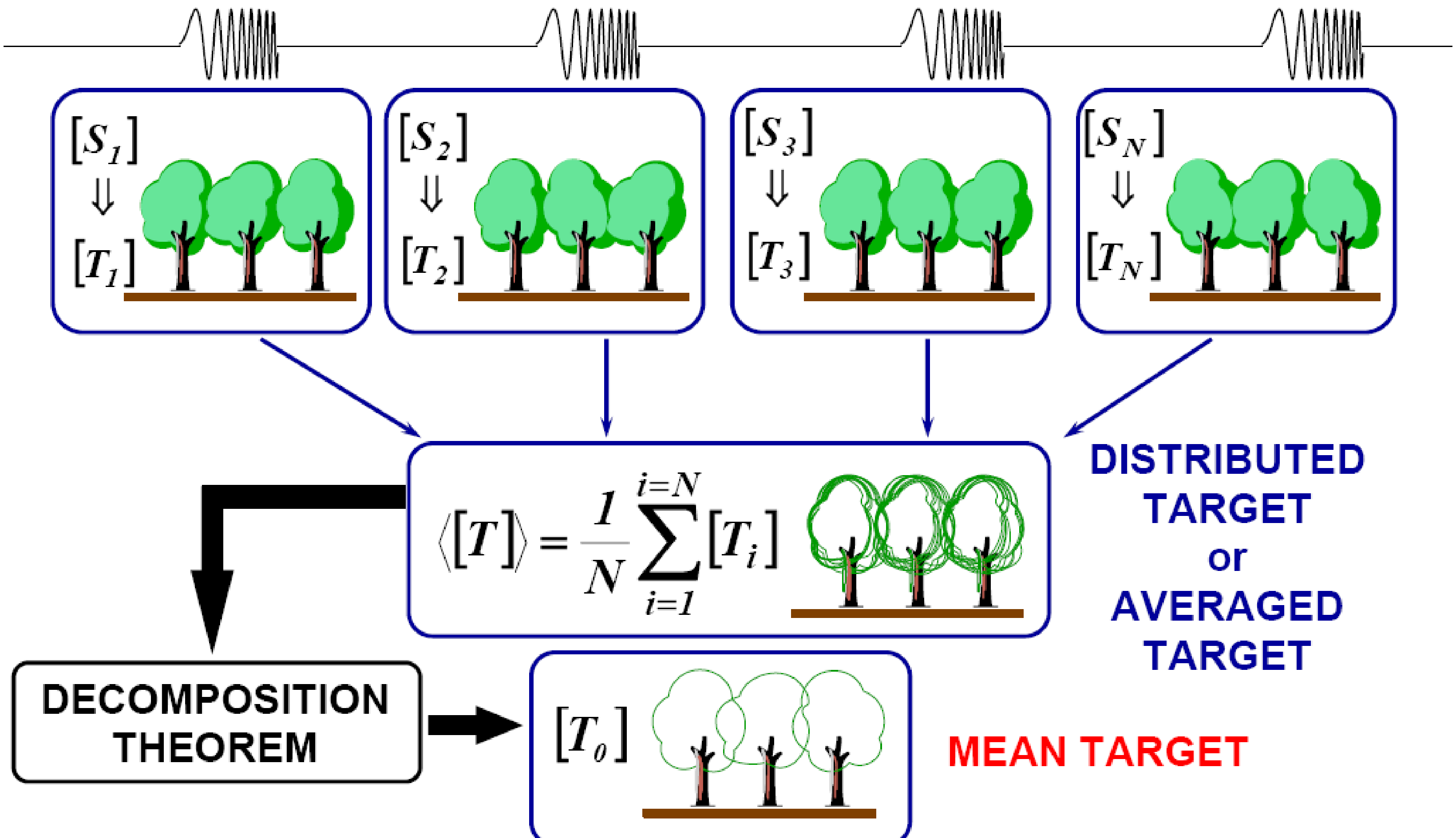
$$\langle G\rangle\left(\langle B_0\rangle+\langle B\rangle\right)\geq\langle C\rangle\langle F\rangle-\langle D\rangle\langle E\rangle$$

$$\langle C\rangle\left(\langle B_0\rangle-\langle B\rangle\right)\geq\langle H\rangle\langle E\rangle+\langle F\rangle\langle G\rangle$$

$$\langle D\rangle\left(\langle B_0\rangle-\langle B\rangle\right)\geq\langle F\rangle\langle H\rangle-\langle G\rangle\langle E\rangle$$

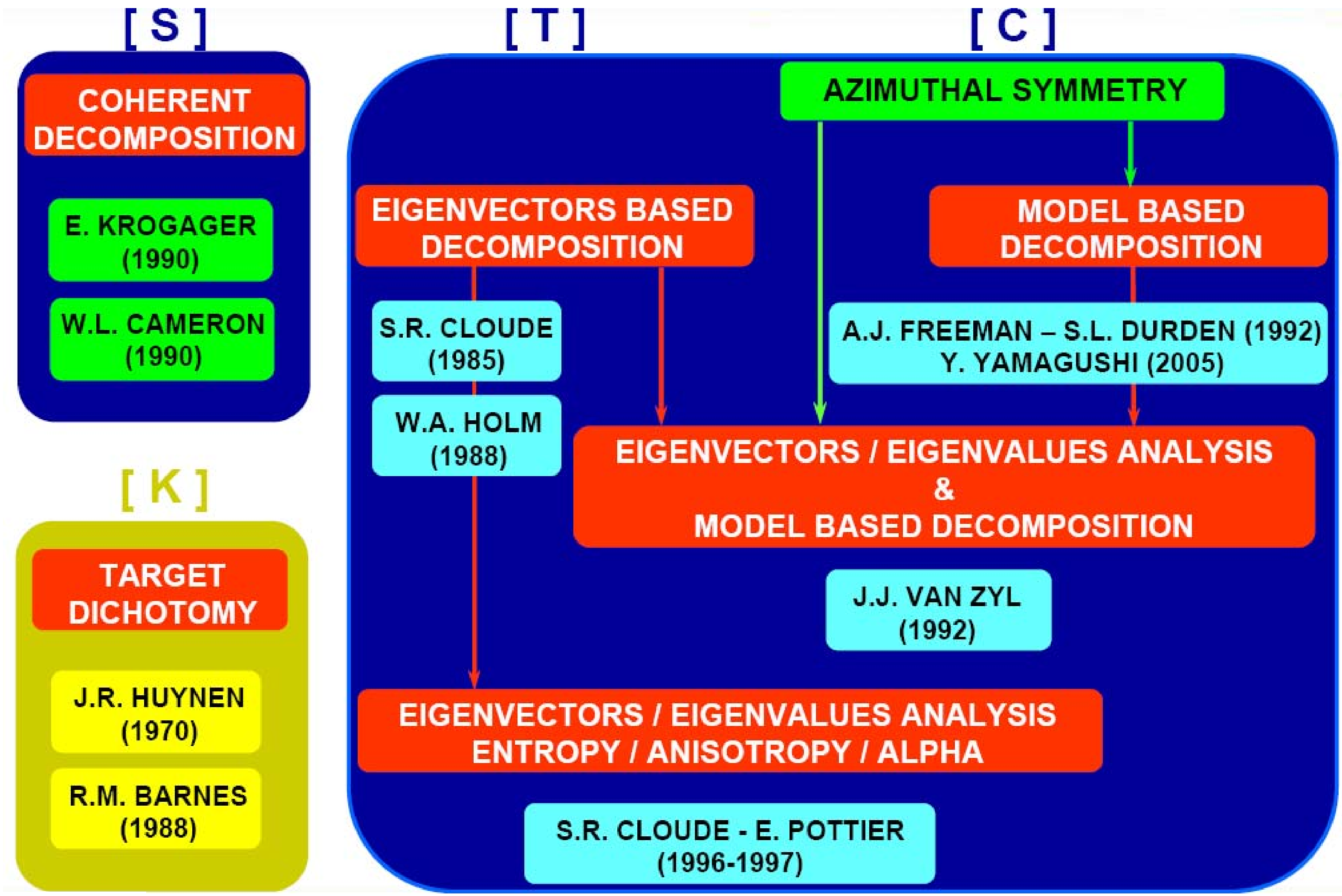
# POLARIMETRIC REMOTE SENSING

## Target Decomposition Theorems



# POLARIMETRIC REMOTE SENSING

## Target Decomposition Theorems



# POLARIMETRIC REMOTE SENSING

## H/A/α decomposition

**TARGET VECTOR**

$$\underline{k} = \frac{1}{\sqrt{2}}\left[S_{XX} + S_{YY} \quad S_{XX} - S_{YY} \quad 2S_{XY}\right]^T$$

**LOCAL ESTIMATE OF THE COHERENCY MATRIX**

$$\langle[T]\rangle = \frac{1}{N}\sum_{i=1}^{N} \underline{k}_i \cdot \underline{k}_i^{*T} = \frac{1}{N}\sum_{i=1}^{N}[T_i]$$

**EIGENVECTORS / EIGENVALUES ANALYSIS**

$$\langle[T]\rangle = [U_3][\Sigma][U_3]^{-1} = \begin{bmatrix} \underline{u}_1 & \underline{u}_2 & \underline{u}_3 \end{bmatrix} \begin{bmatrix} \lambda_1 & 0 & 0 \\ 0 & \lambda_2 & 0 \\ 0 & 0 & \lambda_3 \end{bmatrix} \begin{bmatrix} \underline{u}_1 & \underline{u}_2 & \underline{u}_3 \end{bmatrix}^{*T}$$

**ORTHOGONAL EIGENVECTORS**

**REAL EIGENVALUES** $\lambda_1 > \lambda_2 > \lambda_3$

$$P_i = \frac{\lambda_i}{\sum_{k=1}^{3}\lambda_k}$$

**ENTROPY**

$$H = -\sum_{i=1}^{3} P_i \log_3(P_i)$$

**$\underline{\alpha}$ PARAMETER**

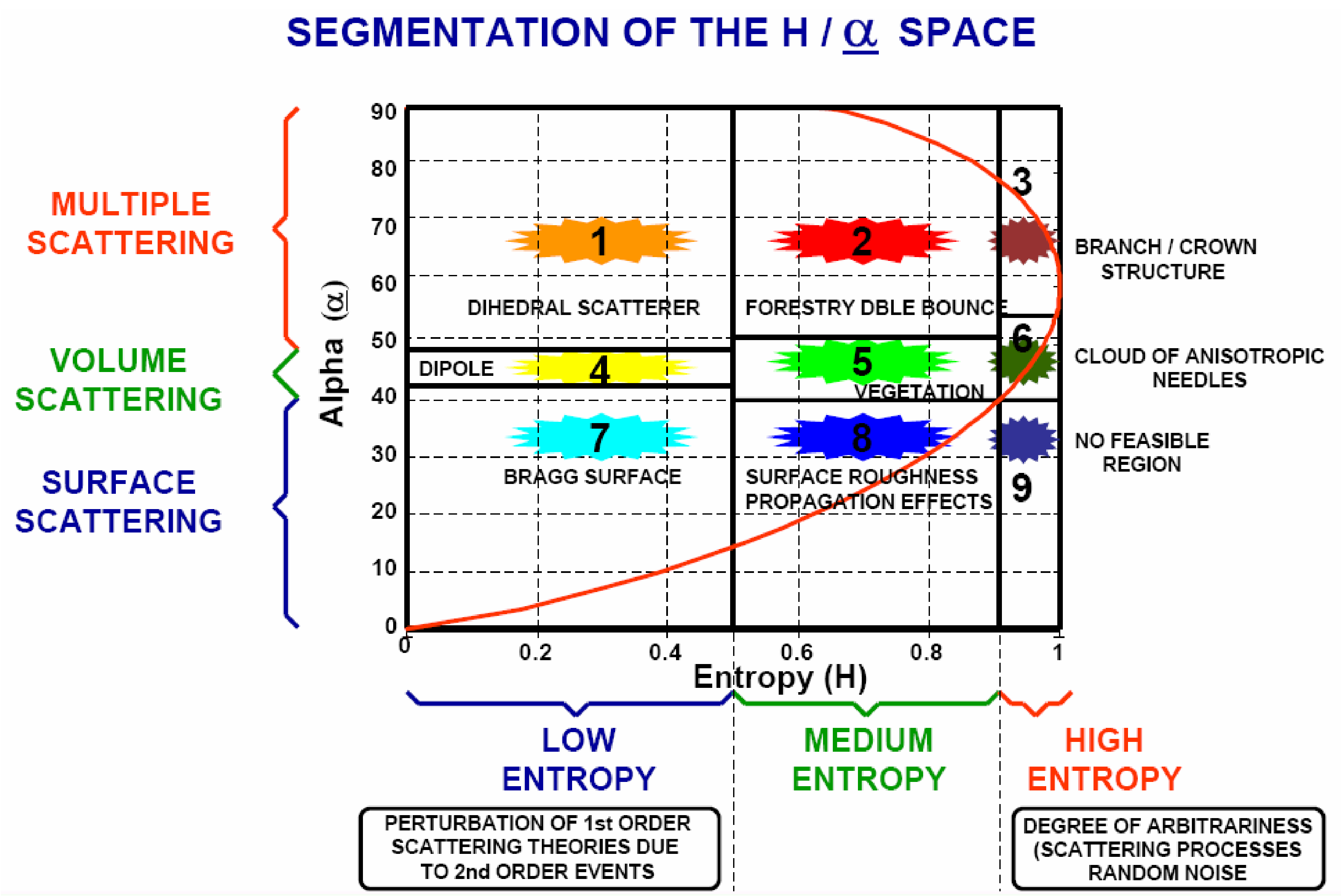
$$\underline{\alpha} = P_1\alpha_1 + P_2\alpha_2 + P_3\alpha_3$$

**ANISOTROPY**

$$A = \frac{\lambda_2 - \lambda_3}{\lambda_2 + \lambda_3}$$

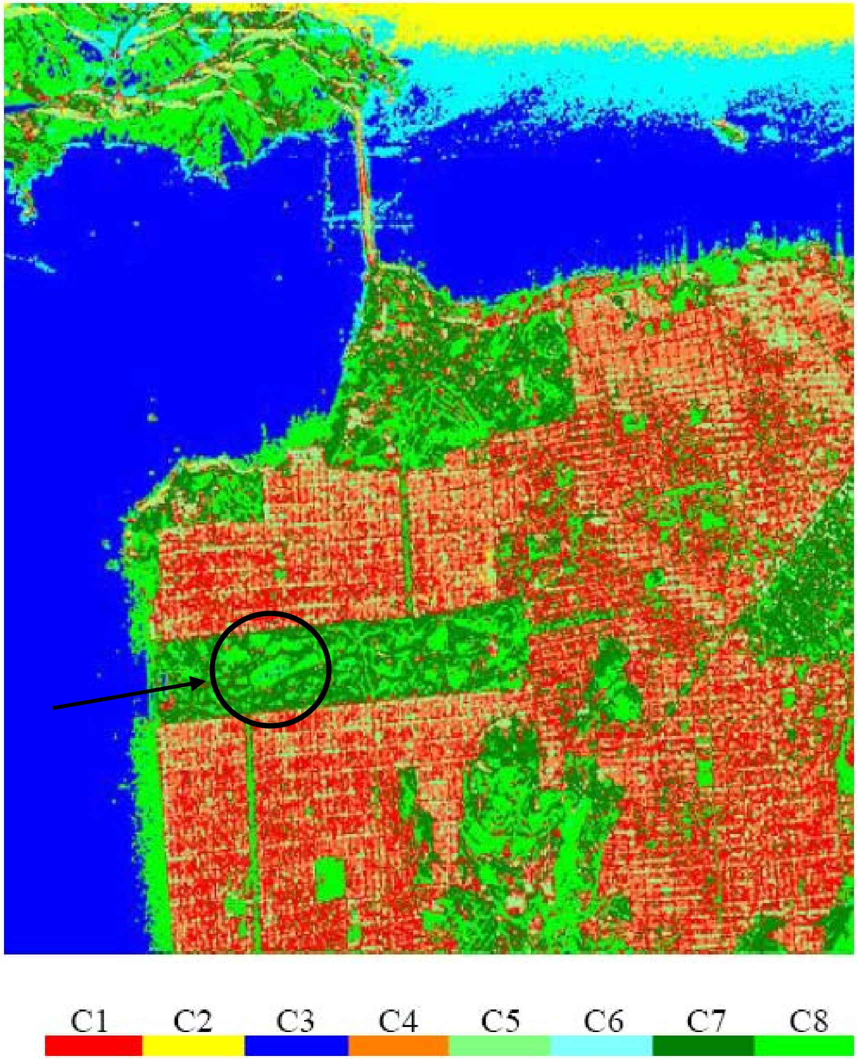
# POLARIMETRIC REMOTE SENSING

## H/A/α decomposition



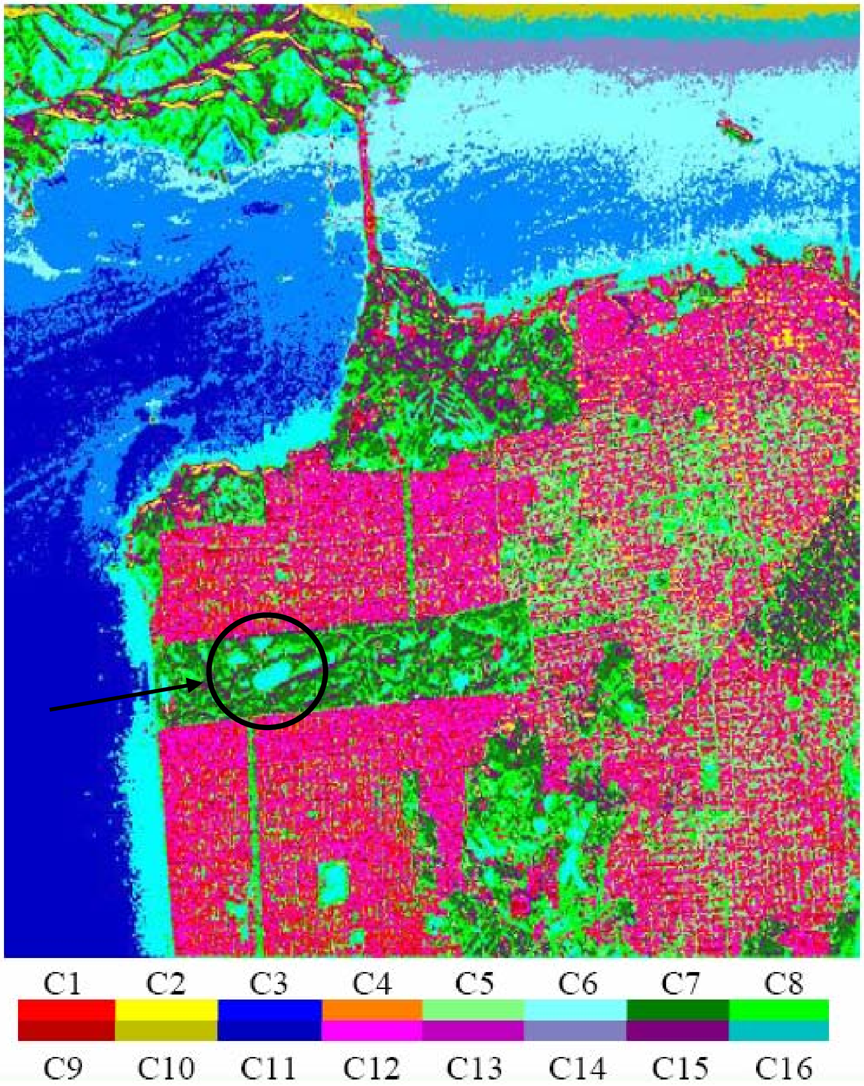
# POLARIMETRIC REMOTE SENSING

## Wishart Classification

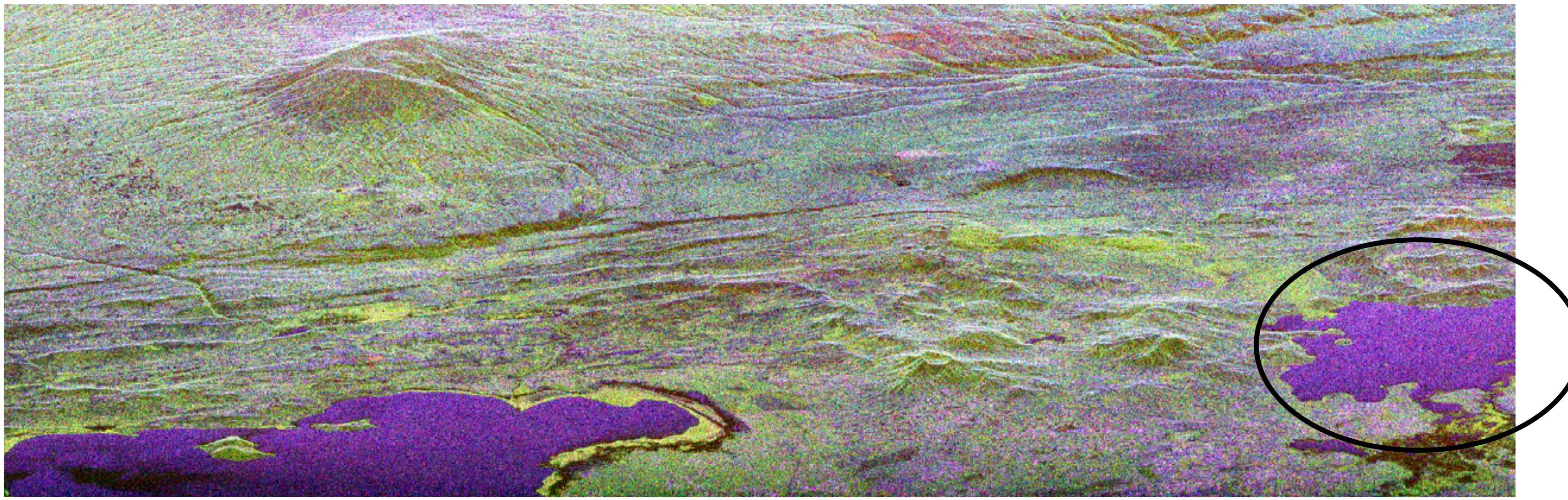
# POLARIMETRIC REMOTE SENSING

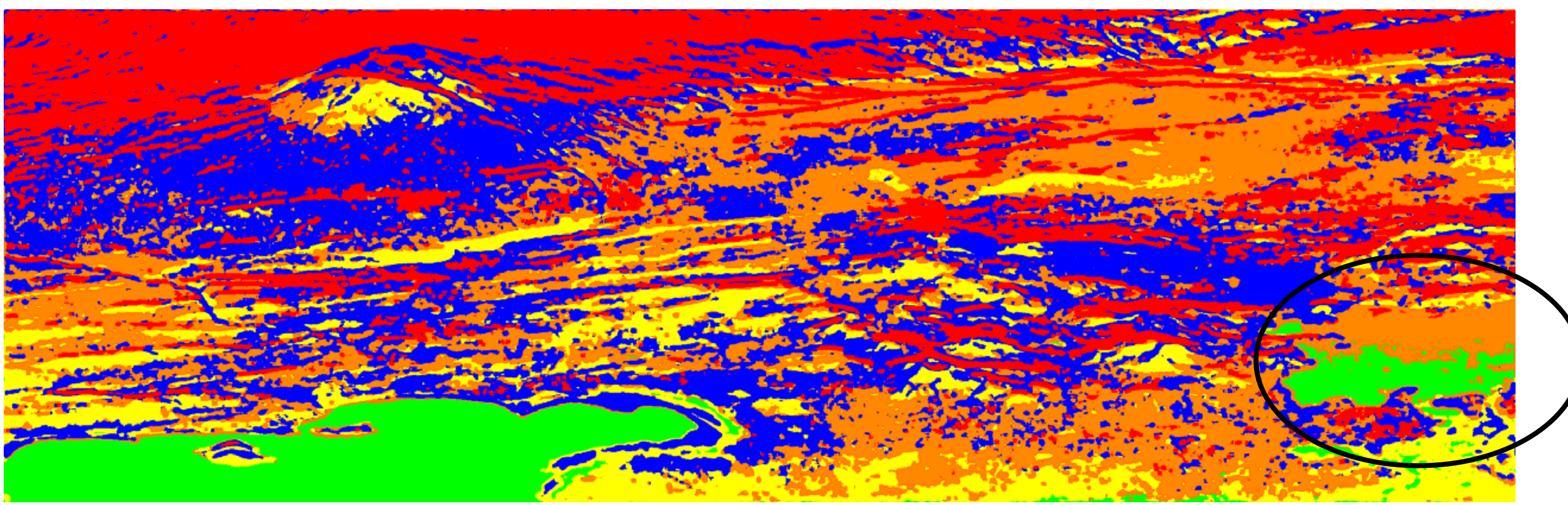
## Wishart Classification

# POLARIMETRIC REMOTE SENSING

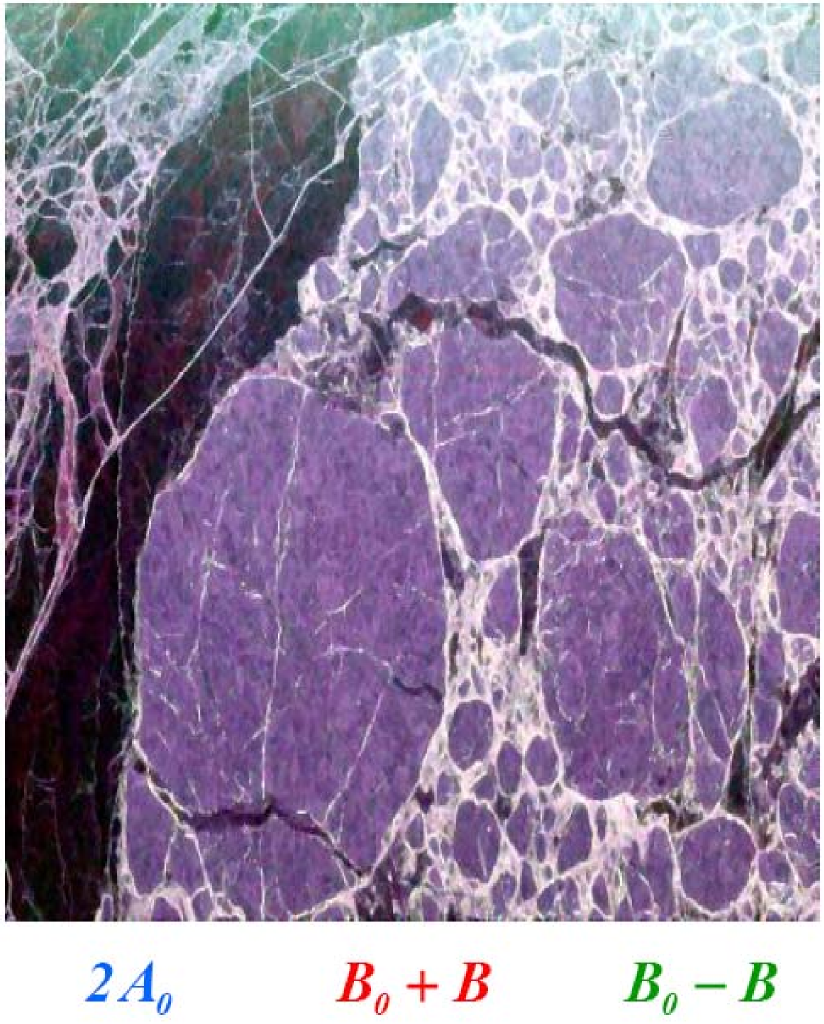
## Wishart Classification – ALOS PALSAR

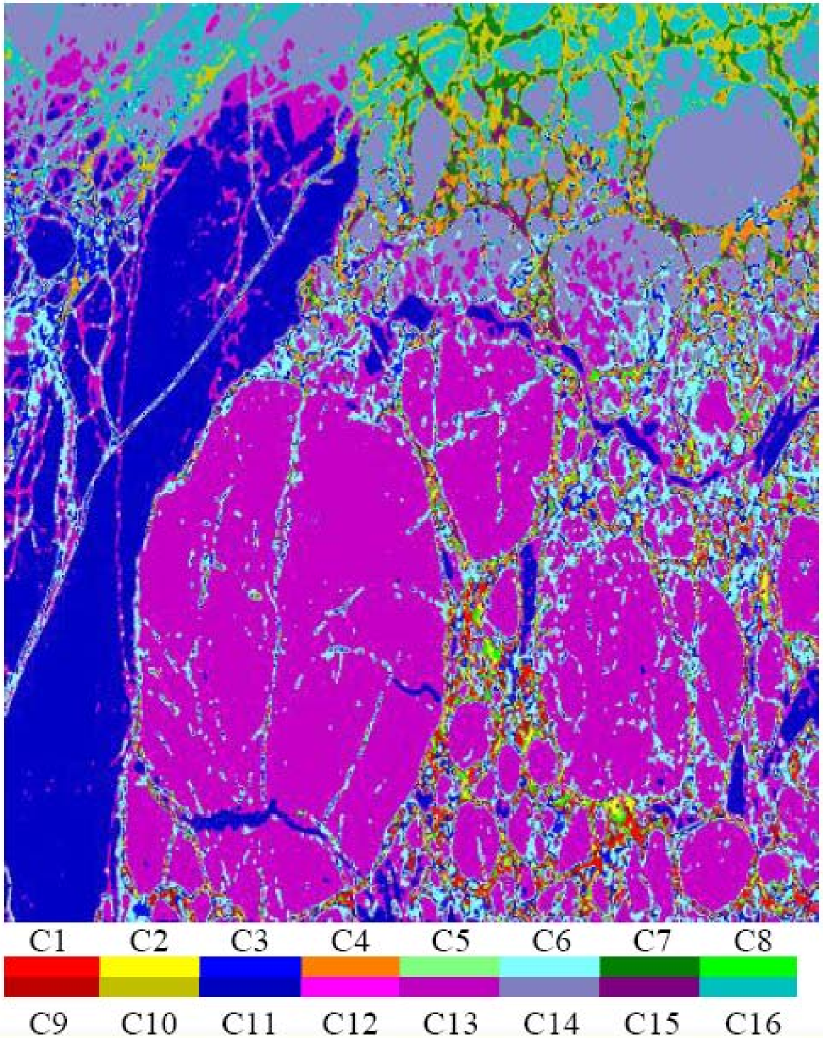




# POLARIMETRIC REMOTE SENSING

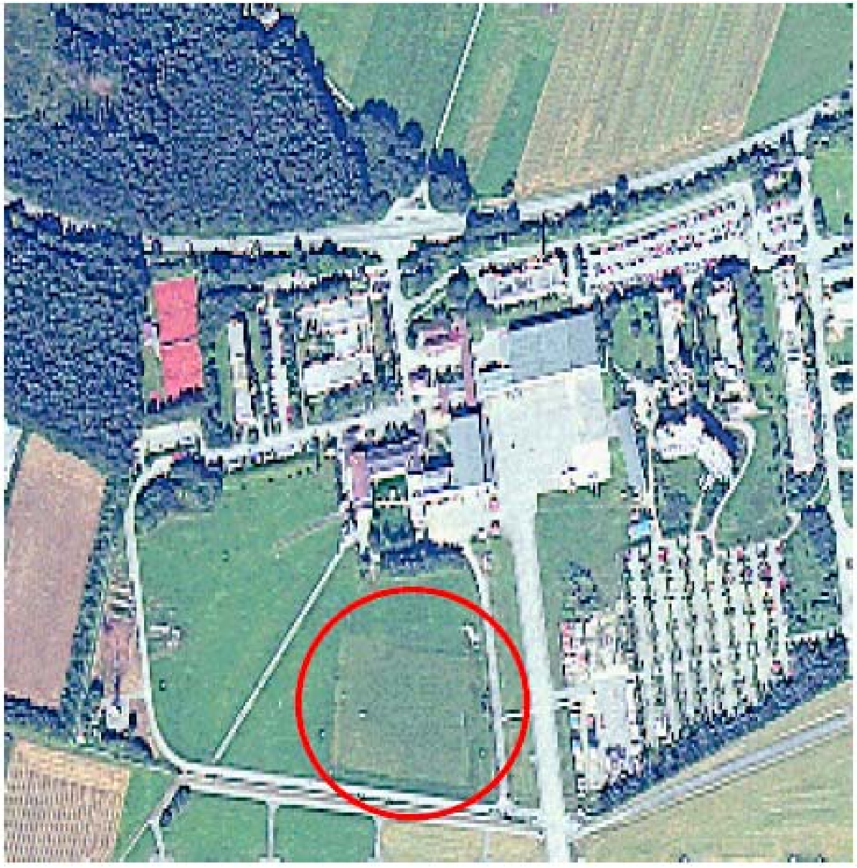
## Ice



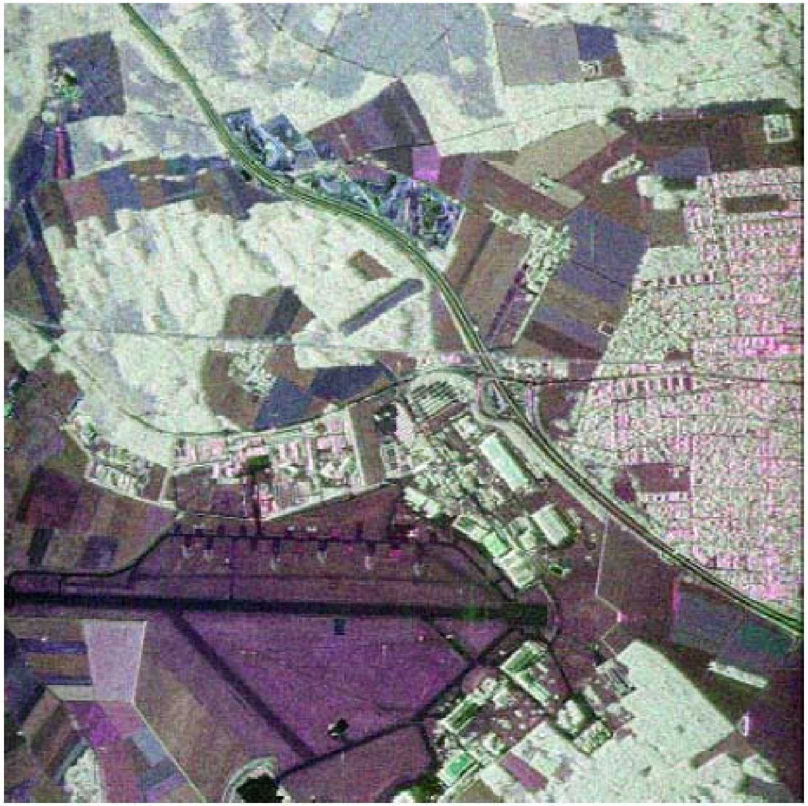
# POLARIMETRIC REMOTE SENSING

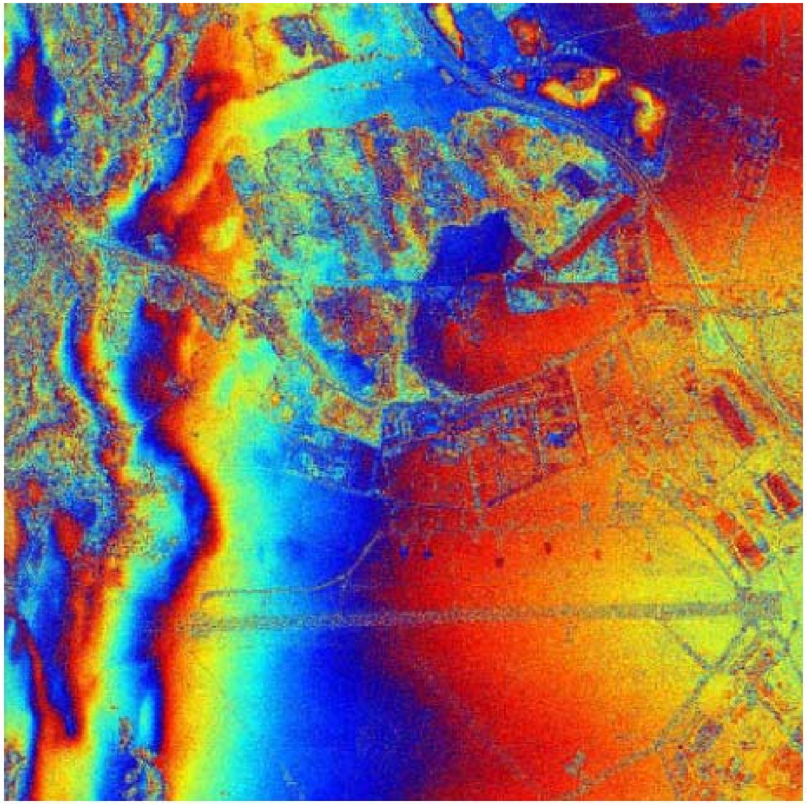
## E-SAR L-band



# POLARIMETRIC INTERFEROMETRIC REMOTE SENSING

# POLARIMETRIC INTERFEROMETRIC REMOTE SENSING





**DLR E-SAR L Band**
**In-Pol SAR (1.5m x 3m) – Baseline 15m**

**POL-SAR INFORMATION**

**IN-SAR INFORMATION** Arg($\gamma$)

# POLARIMETRY at

# TOR VERGATA

# POLARIMETRY at TV

## Thesis topics

**RADAR Polarimetry merges knowledge from several university courses:**

→ Electromagnetism (CEM1&2, Antenne, Propagazione)
→ Modeling and Mathematics (Analisi, Geometria)
→ Remote Sensing (TR1&2, MS)
→ Signal Processing (TT, TTR, ENS)
→ Random Variables and Parameters Estimation (TFA1&2)
→ Informatics (C, Matlab, IDL, Linux OS)

+

***Internship at European Space Agency (ESA-ESRIN)***

+

***"cutting edge" topics and applications!***

**MASTER DEGREE THESIS**

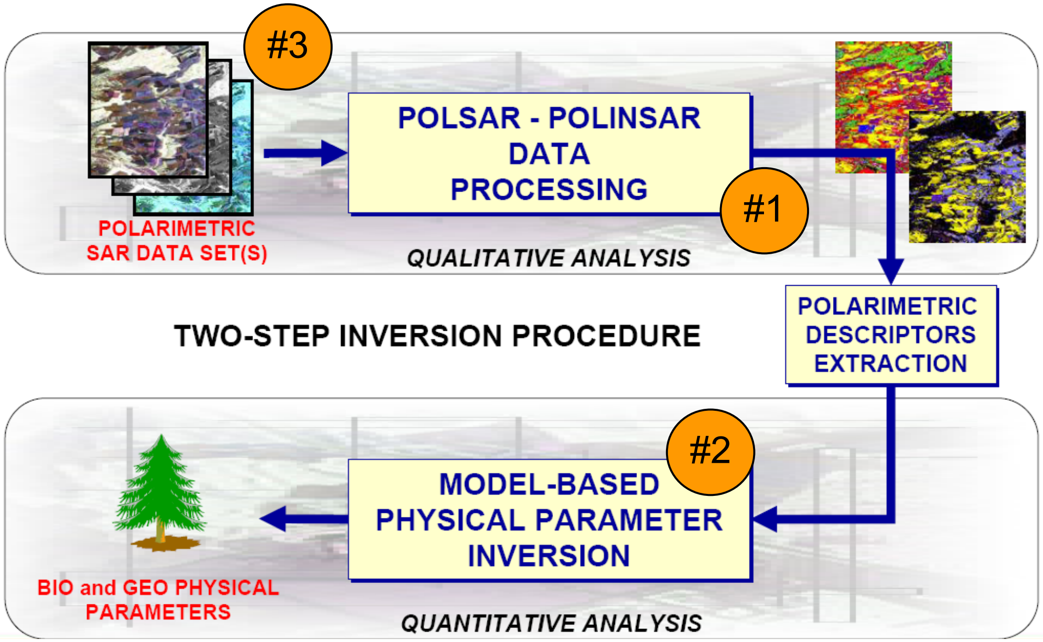
# POLARIMETRY at TV

## Thesis topics

**Topic #1: Exploitation of PALSAR Polarimetric Data**

**Topic #2: Polarimetric and Interferometric Target Modeling**

**Topic #3: PALSAR Polarimetric Calibration (Faraday Rotation Correction)**




**CONTACTS:** *solimini@disp.uniroma2.it*
*lavalle@disp.uniroma2.it*

# Conclusion

**We have seen some basic elements of SAR Polarimetry.**

**Further information available at:**

→ http://earth.esa.int/landtraining07/
→ http://earth.esa.int/polsarpro/

**Thesis Contacts:**

→ *solimini@disp.uniroma2.it*
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***Thank you!***