Instrumental developments and scientific programs at Istituto Ricerche Solari Locarno (IRSOL)

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• **IRSOL** = Istituto Ricerche Solari Locarno

• Observatory specialized in polarimetry
Scientific Staff

- Dr. Michele Bianda
- Dr. Renzo Ramelli
- Dr. Daniel Gisler
- Lucia Kleint (PhD student)

+ Collaborations with other institutes worldwide;
in particular with ETH-Zurich (prof. Jan Stenflo, prof. Svetlana Berdyugina, ...)

Outline

• Instrumentation
  – Telescope + Spectrograph
  – ZIMPOL (new version ZIMPOL3)
  – Why polarimetry at IRSOL?
  – Recent instrumentation:
    • Fabry-Perot filter system
    • Adaptive optics

• Scientific programs
• Future projects
• Conclusion
The IRSOL instrumentation

Telescope

- **Telescope**: Gregory - Coudé, evacuated
  - Diameter of primary mirror: **45 cm**
  - Total focal length: **25 m**

- **Spectrograph**:
  - focal length: **10 m**
  - grating 18 cm × 36 cm
  - 316 lines / mm
  - blaze 63°
Telescope layout
ZIMPOL polarimeter

- **ZIMPOL-polarimeter** (Zurich Imaging Polarimeter, developed at ETH-Zurich) allows precise full Stokes measurements free from seeing induced spurious effects (modulation 42 kHz).

- Polarimetric accuracy depends primarily on photon statistics. $10^{-5}$ level can be reached with long enough exposure time.
ZIMPOL3

New generation camera system
ZIMPOL3

Improvements with respect to ZIMPOL2:

- more efficient and faster
- exposure and readout simultaneously
- larger chip
- based on newer technology (replace components available on the market)
- more flexible system, more functions (readout modes binning, subframe readout, different demudalation schemes, electronic compensation of telescope offset)
- more compact
- easy connection through ethernet from any computer
- night astronomy application: longer integration time, better cooling
Advantages of GCT at IRSOL + ZIMPOL

- Very good polarimetric and spectral accuracy
- Large amount of observing time available:
  - Flexibility, fast reaction to particular solar events
  - Good for monitoring or for projects requiring long observation time
  - Good for testing and development of new instrumentation
- Measurements down to the near UV (390 nm or more)
- Instrumental polarization is small and almost constant over one day of observations (easy to correct – depends on declination only)
Crosstalks

$I \rightarrow Q$

$I \rightarrow U$

$I \rightarrow V$

$Q \rightarrow V$

$U \rightarrow V$
Recent instrumentation

• Fast tunable narrow band filter system
  → monochromatic imaging
  - two lithium niobate Fabry–Perot etalons
  - Bandwidth ~ 30 mA

• AO system
Example of FP recording in the Ca I 4227 Å line

gray scale range ~ 2%

31 August 2006

New setup with FP+spectrograph

- First tests made by Kleint, Feller et al.
- This setup allows to explore any spectral line without having to buy a specific narrow band filter
- Possible to obtain simultaneously on the same CCD two or more monochromatic images at slightly different wavelengths (corresponding to the transmissions peaks of the FP) (ex. 2 wings of a spectral line, or 1 wing + core)
Adaptive optics

Deformable mirror

Tip-tilt mirror

CCD Camera
Scientific programs

Scattering polarization and the Hanle effect

• The high polarimetric accuracy (down to $10^{-5}$ level) allows interesting measurements of scattering polarization (specially near to the limb)

• Scattering polarization & Hanle Effect $\rightarrow$ powerful tool to get information about magnetic fields that are weak or/and tangled on scales below the spatial resolution (to which Zeeman is blind)
Examples of results obtained at IRSOL

- Hanle effect measured in the quiet chromosphere (Bianda et al., 1998)
- Determination of novel constraints on impact polarization in solar flares (Bianda et al., 2005)
- Measurements of polarization in molecular lines (e.g. Berdyugina et al. 2006 ; Asensio Ramos et al. 2004)
- Measurements of full Stokes profiles in prominences in Hα, He-D3 and H β (Ramelli et al., 2005)
- He-D3 full Stokes spectropolarimetric measurements in spicules (Ramelli et al., 2005)
- BaII D2 line observations to verify the theoretical predictions of Belluzzi et al. (Ramelli et al., 2007)
- ....
Future research at IRSOL

• Different observing programs on solar magnetism and polarimetry (with FP or spectrograph)

• Synoptic type programs (eg. Variations of the Hanle-effect signatures with respect to heliographic latitude and solar cycle phase)

• Coordinated type programs with other observatories
  – Simultaneous observations of solar features with complementary sets of instruments
  – Supporting type observations that complement the science of another project
Conclusion

• Interesting research projects mainly in polarimetry and solar magnetism are carried out at IRSOL.

• We are open to new collaborations