• Currently no NIR spectropolarimeter available on 10m-class telescope

• Projects suggested by consortium
  – Based on NIR spectropolarimetry on smaller telescopes
  – Based on 10m class Vis spectropolarimetry
  – Programs as yet unattempted

<table>
<thead>
<tr>
<th>Program</th>
<th>Goal</th>
<th>Type</th>
<th>R</th>
<th>S/N</th>
<th>λ&lt;</th>
<th>J₀</th>
<th>J₁₀</th>
<th>dual beam?</th>
<th>time resolved?</th>
<th>MOS?</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRB Polarization</td>
<td>detect jet-induced polarization, remove ISM</td>
<td>Grating</td>
<td>800</td>
<td>100</td>
<td>1.55</td>
<td>15</td>
<td>18</td>
<td>Yes</td>
<td>Yes</td>
<td>no</td>
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<tr>
<td>AGN spectropolarimetry</td>
<td>Buried AGN, NIR reverberation mapping</td>
<td>Grating</td>
<td>4000</td>
<td>300</td>
<td>1.65</td>
<td></td>
<td></td>
<td>Yes</td>
<td>no</td>
<td>no</td>
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<tr>
<td>Supernova spectropolarimetry</td>
<td>sample full nuclear processing</td>
<td>Grating, Imaging</td>
<td>800</td>
<td>1000</td>
<td>1.65</td>
<td>11</td>
<td>15</td>
<td>Yes</td>
<td>Yes</td>
<td>no</td>
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<tr>
<td>Galaxy ejecta mapping</td>
<td>3D geometry of ejected matter</td>
<td>FP</td>
<td>2500</td>
<td>100</td>
<td>1.3</td>
<td>diffuse</td>
<td>helps</td>
<td>no</td>
<td>no</td>
<td></td>
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<tr>
<td>Atomic Fluorescence</td>
<td>New magnetic field mapping technique</td>
<td>Grating, FP</td>
<td>10000</td>
<td>2500</td>
<td>1.3</td>
<td>diffuse</td>
<td>helps</td>
<td>no</td>
<td>no</td>
<td></td>
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<tr>
<td>PreMS disks</td>
<td>study disks in embedded objects</td>
<td>Grating</td>
<td>4000</td>
<td>300</td>
<td>1.3</td>
<td>7</td>
<td>12</td>
<td>no</td>
<td>no</td>
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<tr>
<td>Magnetic CV’s</td>
<td>lower magnetic fields in polars</td>
<td>Grating all-Stokes</td>
<td>800</td>
<td>100</td>
<td>1.6</td>
<td>13</td>
<td>16</td>
<td>Yes</td>
<td>some</td>
<td>no</td>
</tr>
</tbody>
</table>
POLARIMETRIC MODES

• **Grating spectropolarimetry**
  – Any grating setup
  – MOS possible with 4’ by 8’ slitmask

• **Imaging polarimetry**
  – Filterless: chromatic splitting makes 20” “objective prism” very low res spectro-polarimetry
  – MOS for faint objects
  – FP filters with or without FP for diffuse objects

• **Fabry-Perot spectropolarimetry**
  – Unique on any telescope; appropriate for big glass
  – Beamsplitter after FP guarantees λ match of FP wings

May 20 & 21, 2009

Orion Neb
Ha

M30 unfiltered

SN2006mr
300 l/mm
SUCCESSFUL SPECTROPOLARIMETRY

- Successful spectropolarimetry of SNe only since introduction of 10m-class spectropolarimeters
- Continuum polarization from electron scattering in distorted pseudo-photosphere
  - SNIa: peaks ~0.3% at max, gone at +2 weeks: => outer part asymmetric, core not
  - Core collapse: increases after max many %: core explosion asymmetric
- Line polarization from asymmetric blocking of photosphere
  - SNIa: different elements polarized differently => explosive nuclear processing introducing clumps
NIR SNIa Spectropolarimetry

- Visible samples O, Mg, Si, Ca
- NIR also samples Fe-Peak: Fe, Ni, Co, Mn
- Vis + NIR line pol vs. time => geometry of explosion throughout explosion: compare with explosion codes, progenitor candidates
- Survey of dozens of different SNIa: difference between luminous & underluminous subtypes, possible existence of short-onset progenitors
- R = 800 grating spectropolarimetry, dual beam due to rapid development; imaging polarimetry Vis and NIR of field to get foreground interstellar polarization
- SALT queue mode allows for optimal scheduling of observations
Yan & Lazarian (2006–2008) suggest polarization of atomic scattering can be diagnostic of magnetic field.

In principle, a new magnetic field diagnostic for ISM, better than HI Zeeman.

“Nonalignable” atom J(grnd) < 1:
- SiII, MgII
- Primary fluorescence gives circumsymmetric pol => scattering angle

“Alignable” atom J(grnd) ≥ 1:
- OI, NI, AlII, [FeII], [CrII], [NiII]
- Illumination from one side pumps non-isotropic angular momentum distribution, realigned by Larmor precession in magnetic field < 1 μGauss in ISM.
- Primary fluorescence from aligned state is polarized, depends on scattering angle and 3D orientation of magnetic field.

Effect seen in Sun, not elsewhere due to lack of instrumentation.
FLUORESCENCE TARGETS

• Observed in HII, but weak and confused by other excitation processes

• Should be sole emission lines in neutral gas, e.g. reflection nebulae (star form regions), extend later to other environments (e.g. circumstellar, circumgalactic)

• First verified by RSS-VIS “performance verification” observation of NGC2023
  – R ~ 9000, three colors, 8’ x 0.6” slit, ~1000 secs
  – HI Balmer from foreground gas,
  – $H_2$ fluorescence in PDR (14 lines)
  – NI, OI, SiII, fluorescence (8 lines);
  – [FeII], [NiII], [CrII] (10 lines) metastable states pumped by fluorescence
  – Demonstrates RSS Grasp

Nonalignable  Alignable  Maybe
RSS-VIS NGC2023 SPECTRUM

300 secs

3800  4000  4200  4400

No ID  HI  [FeII]

900 secs

5400  5600  5800  6000  6200  6400

OI  SIII  HII

1500 secs

7300  7500  7700  7900  8100  8300  8500

FeII  HII  [CrII]  OI

RSS-NIR MTR  POLARIMETRY
VIS, NIR POLARIMETRY

- Predicted line equivalent widths
  - better for fainter reflection nebulae
  - NIR strong primary fluorescence from NI, OI (aligned), MgII (nonaligned): best place to look!
- Grating spectropolarimetry R=10,000 to verify best polarized lines. VIS: 1 Track SN <~ 100
- FP spectropolarimetry of
  - Unpolarized nonaligned line (ISPol map)
  - Polarized nonaligned atom => scattering map
  - Aligned atom => B-field 3D map
  - VIS: 30 spatial pixels SN > 100